Ontario

Apprenticeship
In-school Curriculum Standards

Heavy Duty Equipment Technician

Level 3

421A

Ministry of Training, Colleges and Universities

Apprenticeship
In-school Curriculum Standards

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Introduction

The Heavy Duty Equipment Level 3 curriculum has been developed in keeping with the prescribed Ministry of Training, Colleges and Universities (MTCU) Training Standards, which are common in the two trades of Agricultural Equipment Technician and Heavy Duty Equipment Technician. The curriculum layout used provides an opportunity to cross-reference the in-school learning outcomes and content to the specific workplace Training Standards.

For easy reference, a time allocation has been included for each reportable subject, along with the Theory/Practical breakdown for the delivery of the Learning Content. More detailed time allocations for the instructor have been provided for each topic area to assure consistency for each apprentice intake.

The continual introduction of innovative techniques and more complex equipment is resulting in increasing demands for tradespersons who are not only skilled in the practical aspects of the trade, but who also have a sound theoretical knowledge of the inspecting, diagnosing, repair, and servicing requirements. The curriculum has been developed to provide this theoretical knowledge and to offer some practical applications to complement the on-the-job work experiences of the Heavy Duty Equipment apprentice.

The objective of the curriculum, therefore, is to provide a basis for:

a. Sound theoretical training that meet the challenges presented by the increasingly more complex equipment designs and testing techniques.
b. A reinforcement of fundamental skills of the trade through the exposure to practical applications.
c. Developing in the apprentices high standards of craftsmanship, problem-solving skills, and personal pride in their trade.
d. Developing desirable work attitudes and a keen sense of responsibility, particularly concerning public and personal safety.

The curriculum has been designed to give the instructor every reasonable opportunity for flexibility and innovation without deviating to any significant degree from the subject requirements, as determined by the Industry Committees and as prescribed in the Regulations for the Trades. Since the scope of the prescribed curriculum is quite extensive, the apprentices must be expected to reinforce the acquired knowledge through regular independent out-of-classroom assignments. The curriculum has been presented in a chronological sequence in keeping with sound teaching methodologies. However, the actual application of the sequence may differ somewhat between colleges because of scheduling, staffing, and facilities utilization.

The curriculum includes specific references to the Ministry of Training, Colleges and Universities Apprenticeship Training Standards. While these references to various performance objectives in the Training Standards have been linked to the respective in-school outcomes, employers should not assume complete coverage to a journeyperson level. The in-school delivery focuses primarily on the knowledge required to master the respective objectives outlined in the Training Standards. Employers, therefore, are expected to complete the training of these respective objectives by applying the prescribed in-school knowledge to the required practical learning experienced in the work setting.

To ensure that apprentices will be able to successfully demonstrate the learning outcomes according to performance criteria, specific times have been allocated in the respective areas to allow for some applications enhancement. It is of utmost importance that all application assignments relate to prescribed experiences only. Time constraints will not permit engaging apprentices in tasks of limited learning benefit that are unrelated to the curriculum outcomes. In the Learning Content section, whenever an assigned operation for an applied test or repair procedure indicates that a demonstration should be performed, there is only enough time allocated for the instructor to perform the activity.

Regular evaluations of the apprentices' learning achievements must be performed in both theory and practical applications throughout the program to ensure consistency with learning outcome expectations. Testing of apprentice knowledge and skills will take place during the allotted delivery hours for each unit. In addition to providing an evaluation of apprentice competency, the review of test question answers is considered to be a valuable learning opportunity.

In all practical activities, the apprentices will observe the Occupational Health and Safety Act and the applicable regulations including use of personal protective equipment. Institutional regulations and policies may also apply.

Participation by Stakeholders

A consortium of six colleges of applied arts and technology, working in collaboration with the Ministry of Training, Colleges and Universities and industry stakeholders, participated in the development of this document. The development and subsequent revisions were based on the training standards that were previously revised by the MTCU in consultation with industry advisory groups. The development was completed using a process and format approved by MTCU.

Participating Colleges

- Cambrian College of Applied Arts and Technology (Project Lead) (HDET Level 3 Lead)
- Algonquin College of Applied Arts and Technology
- Centennial College of Applied Arts and Technology
- Fanshawe College of Applied Arts and Technology
- Mohawk College of Applied Arts and Technology
- Sault College of Applied Arts and Technology

Industry Representatives:

Equipment World Ltd	Elmira Farm Service Ltd
Sudbury Truck & Trailer Ltd	Liftow Inc.
Toromont CAT Ltd	Vale Inco Ltd
Nortrax Ltd	Volvo Canada Ltd
Xstrata Nickel Ltd	Atlas Copco Construction & Mining Canada Ltd
McGavin Farm Equipment Ltd.	

The first step in the development process was to assemble a Project Steering Committee (PSC), consisting of both industry representatives and apprenticeship in-school deliverers. The PSC initiated the plan for the project development that followed. The PSC established six working teams, each responsible for the development of in-school apprenticeship curriculum documents for the specific motive power trades listed below:

- Level 1 common to Agricultural Equipment, Heavy Duty Equipment, Powered Lift Truck, and Truck and Coach
- Level 2 common to Agricultural Equipment and Heavy Duty Equipment
- Level 3 specific to Agricultural Equipment
- Level 3 specific to Heavy Duty Equipment
- Level 2 and 3 specific to Powered Lift Truck
- Level 2 and 3 specific to Truck and Coach

The six teams worked with advisory groups during the development of the curriculum. The advisory groups were industry representatives who ensured content validity. During various stages of the process, the PSC and participating industry advisory groups evaluated the draft curriculum documents and provided feedback and recommendations for revisions.

Heavy Duty Equipment Technician

Level 3

Program Summary of Reportable Subjects - Level 3

Reportable Subjects	Total	Theory	Practical
1.Trade Practice	24	8	16
2. Fluid Power Systems	48	30	18
3. Engine Systems	24	16	8
4. Electrical/Electronic Systems	40	23	17
5. Fuel Systems	40	26	14
6. Drive Train Systems	32	16	16
7. Brake, Track and Suspension Systems	32	18	14
Total	**240**	**148**	**92**

Number: **S1255**

Reportable Subject: **TRADES PRACTICES**

Duration: Total 24 hours Theory 8 hours Practical 16 hours

Prerequisites: CVAE Level 2

Co-requisites: None

1.1 Shielded Metal Arc Welding (SMAW)

12 Total Hours Theory: 4 hours Practical: 8 hours

1.2 Metal Inert Gas (MIG) Welding

12 Total Hours Theory: 4 hours Practical: 8 hours

Evaluation Structure: Assignments related to theory and appropriate application skills.
Proctored final exam.
Periodic quizzes.

Mark Distribution:

Theory Testing	Practical Application Testing
50%	50%

Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:

Recommended Minimum Equipment:

Shielded Metal Arc Welder	Chipping hammers
Metal Inert Gas Welder	Hand grinders
Selection of filler rods and consumables	Personal Protective Equipment specific to welding

S1255.1 **Shielded Metal Arc Welding (SMAW)**

Duration: Total 12 hours Theory 4 hours Practical 8 hours

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:

HDET 5892.03, 5897.03, 5897.06, 5899.03, 5899.06, 5900.03, 5903.03, 5904.06, 5906.03

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to perform shielded metal arc welding procedures following manufacturers' recommendations, government regulations, and safe work practices.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

1.1.1 Explain the purpose and fundamentals of the shielded metal arc welding process.

[0.5/0]

- **metallurgy**
- **arc emissions**
- **electrical polarity**
- **electrical fundamentals**

1.1.2 Identify the function, construction features, and application of shielded metal arc welding equipment and consumables.

[1/0]

- **transformers**
- **rectifiers**
- **controls**
- **electrode holders**
- **electrode specifications**
  - codes
  - current type and polarity
  - position
  - penetration
  - base metal material
  - material condition
- **duty cycle**

1.1.3 Describe the principles of operation of shielded metal arc welding equipment.

[1.5/0]
- **equipment settings**
- **transformers**
- **rectifiers**
- **stationary and portable units**
- **closed circuit voltage**
- **open circuit voltage**

1.1.4 Perform inspection and diagnostic procedures following manufacturers' recommendations of shielded metal arc welds.

[0.5/2]
- **describe and diagnose defective welds**
  - porosity
  - lack of penetration
  - excessive heat
  - contamination
- **identify causes of defective welds**

1.1.5 Identify maintenance procedures for shielded metal arc welding equipment following manufacturers' recommendations.

[0.5/0]
- **welding cables**
- **holding devices**
- **power sources**
- **protective equipment**

1.1.6 Perform the assigned shielded metal arc welding procedures following manufacturers' recommendations and safe work practices.

[0/6]
- **machine adjustments and welds**
- **trial beads**
- **single and multi pass butt and fillet welds in flat position**

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye, face, hand, foot, and clothing protection
  - fire prevention
  - ventilation
  - cut and burn treatments
  - flammable container welding precautions
  - electrical shock prevention
  - vehicle electronic protection
  - butane lighters
  - flash protection
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1255.2 **Metal Inert Gas (MIG) Welding**

Duration: Total 12 hours Theory 4 hours Practical 8 hours

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:

HDET 5893.03, 5897.03, 5897.06, 5899.03, 5899.96, 5900.03, 5903.03, 5904.06, 5906.03

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to perform metal inert gas (MIG) welding procedures following manufacturers' recommendations, government regulations, and safe work practices.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

1.2.1 Explain the purpose and fundamentals of the metal inert gas (MIG) welding process.

[0.5/0]
- **electrical fundamentals**
- **electrical polarity**
- **power sources**
- **wire feeders**
- **gas shielding**

1.2.2 Identify the function, construction features, composition, types, and application of metal inert gas (MIG) welding equipment and consumables.

[0.5/0]
- **power sources**
  - rectifier
  - generator
  - inverter
- **consumables**
  - wire types
  - wire specifications
  - wire sizes
  - shielding gases
  - contact tips

1.2.3 Describe the principles of operation and set-up of metal inert gas (MIG) welding equipment.

[1.5/1]
- **gun angle and travel**
- **wire drive**
  - pressure
  - speed
  - groove design

- **contact tip**
  - cleanliness
  - gas flow
  - wire speed
- **voltage setting**
  - metal thickness and type
- **shielding gas**
  - flow rate

1.2.4 Perform inspection and diagnostic procedures of metal inert gas (MIG) welding operations.

[1/1]

- **inspect and diagnose weld defects**
  - spatter
  - porosity
  - lack of penetration
  - excessive heat
  - wire speed
    - too fast
    - too slow
  - shielding gas
    - selection
    - flow rate

1.2.5 Identify maintenance procedures for metal inert gas (MIG) welding equipment following manufacturers' recommendations.

[0.5/0]

- **drive roll pressure**
- **cable conduit cleanliness**
- **contact tip condition**
- **gas nozzle condition**

1.2.6 Perform assigned operations for metal inert gas (MIG) welding procedures following manufacturers' recommendations and safe work practices.

[0/6]

- **weld deposits on lap and "T" joints**
- **adjustments to:**
  - voltage
  - wire speed
  - gas flow
  - electrode protrusion

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye, face, hand, foot, and clothing protection
  - fire prevention
  - ventilation
  - cut and burn treatments
  - flammable container welding precautions
  - electrical shock protection
  - vehicle electronic protection
  - flash protection
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

Number: **S1256**

Reportable Subject: **FLUID POWER SYSTEMS**

Duration: Total 48 hours Theory 30 hours Practical 18 hours

Prerequisites: CVAE Level 2

Co-requisites: None

2.1 Hydraulic Principles

4 Total Hours Theory: 4 hours Practical: 0 hours

2.2 Hydraulic Schematics and Circuit Design

6 Total Hours Theory: 6 hours Practical: 0 hours

2.3 Hydraulic Accumulators and System Components

7 Total Hours Theory: 4 hours Practical: 3 hours

2.4 Hydraulic Actuators

10 Total Hours Theory: 6 hours Practical: 4 hours

2.5 Electronically Managed Hydraulic Systems

8 Total Hours Theory: 6 hours Practical: 2 hours

2.6 Hydraulic System Diagnosis

13 Total Hours Theory: 6 hours Practical: 7 hours

Evaluation Structure: Assignments related to theory and appropriate application skills.
Proctored final exam.
Periodic quizzes.

Mark Distribution:

Theory Testing	Practical Application Testing
60%	40%

Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:

O.E.M. Equipment Documentation

Recommended Minimum Equipment:

Equipment with open centre hydraulic system	Hydraulic flow meters
Equipment with closed centre hydraulic system (pressure compensated)	Pressure testing equipment: mechanical gauges, electronic gauges
Equipment with closed centre hydraulic system (pressure and flow compensated)	Hydraulic cylinders and motors
Equipment with hydraulic systems that use accumulators	Assortment of vane, piston and gear pumps and motors
Axial piston pumps	Electro hydraulic components

S1256.1 **Hydraulic Principles**

Duration: Total 4 hours Theory 4 hours Practical 0 hours

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:

HDET 5895.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to interpret hydraulic system schematics following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

2.1.1 Explain the fundamentals of hydraulic circuits and schematics.

[0.5/0]
- **graphic symbols**
- **hydraulic circuit layouts**
- **pictorial drawings**
- **diagrams**
- **schematics**
- **Society of Automotive Engineers (SAE)**
- **International Standards Organization (ISO)**

2.1.2 Identify hydraulic component on diagrams and schematics.

[0.5/0]
- **component relationships**
- **graphic symbols**

2.1.3 Describe the oil flow circuit path through various hydraulic system diagrams and schematics.

[1.5/0]
- **open centre systems**
  - series connections
  - series-parallel connections
- **closed centre systems**
  - fixed displacement pump
  - variable displacement pump
- **interpret graphic symbols as applied to system circuit schematics**

2.1.4 Perform calculations of hydraulic circuit applications.

[1.5/0]
- **pressure**
- **force**
- **area**
- **delivery**
- **cycle times**
- **power**

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye and hand protection
  - high pressure concerns for skin penetration
  - chemical hazards—WHMIS
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1256.2 **Hydraulic Schematics and Circuit Design**

Duration: Total 6 hours Theory 6 hours Practical 0 hours

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:

HDET 5895.02, 5895.05, 5895.08

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to evaluate hydraulic circuit design and compare with manufacturers' schematics.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

2.2.1 Explain the purpose and fundamentals of hydraulic systems.

[2/0]

- **open centre systems**
  - series connections
  - parallel connections
  - series-parallel connections
  - power beyond
  - flow dividers
- **closed centre systems**
  - fixed displacement pump and accumulators
  - variable displacement pump
  - pressure compensated
  - power beyond
  - pressure and flow compensated
- **special flow systems**
  - demand
  - summation
  - pressure compensated
  - flow compensated

2.2.2 Identify the construction features of hydraulic systems.

[2/0]

- **open centre systems**
  - series connections
  - parallel connections
  - series-parallel connections
  - power beyond
  - flow dividers

- **closed centre systems**
  - fixed displacement pump and accumulators
  - variable displacement pump
  - pressure compensated
  - power beyond
  - pressure flow compensated
- **special flow systems**
  - demand
  - summation
  - pressure compensated

2.2.3 Describe the principles of operation of hydraulic systems.

[2/0]

- **open centre systems**
  - series connections
  - parallel connections
  - series-parallel connections
  - power beyond
  - flow dividers
- **closed centre systems**
  - fixed displacement pump and accumulators
  - variable displacement pump
  - pressure compensated
  - power beyond
  - pressure flow compensated
- **special flow systems**
  - demand
  - summation
  - pressure compensated

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye and hand protection
  - high pressure concerns for skin penetration
  - chemical hazards
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1256.3 **Hydraulic Accumulators and System Components**

Duration: Total 7 hours Theory 4 hours Practical 3 hours

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:

HDET 5895.02, 5895.03, 5895.04, 5895.05, 5895.06, 5895.07, 5895.08, 5895.09, 5895.10

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to recommend repairs for hydraulic accumulators and accessories following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

2.3.1 Explain the purpose and fundamentals of hydraulic accumulators and hydraulic components.

[0.5/0]
- **accumulator safety precautions**
- **accumulator types**
  - pneumatic (gas charged)
    - bladder
    - piston
    - diaphragm
  - spring loaded
  - weighted
- **intensifiers**
- **switches**
- **gauges**
- **sensors**
  - pressure
  - flow
  - temperature
- **solenoids**
- **component graphic symbols**

2.3.2 Identify the construction features of hydraulic accumulators and hydraulic components.

[1/0]
- **accumulators**
  - pneumatic (gas charged)
    - bladder
    - piston
    - diaphragm
  - spring loaded
  - weighted

- **intensifiers**
- **switches**
  - pressure
  - temperature
  - limit
- **sensors**
  - pressure
  - flow
  - temperature
  - position

2.3.3 Describe the principles of operation of hydraulic accumulators and hydraulic components.

[2/0]

- **accumulators**
  - pneumatic (gas charged)
    - bladder
    - piston
    - diaphragm
  - spring loaded
  - weighted
- **intensifiers**
- **switches**
  - pressure
  - temperature
  - limit
- **sensors**
  - pressure
  - flow
  - temperature
  - position

2.3.4 Demonstrate inspection, testing, and diagnostic procedures following manufacturers' recommendations to hydraulic accumulators and hydraulic components.

[0/2]

- **internal and external leakage of accumulators**
- **examine defective components**
- **intensifiers**
- **gauges**
- **sensors**
  - pressure
  - flow
  - temperature
  - position
- **switches**
  - pressure
  - temperature
  - limit

2.3.5 Recommend reconditioning or repairs following manufacturers' recommendations to hydraulic accumulators and hydraulic components.

[0.5/1]
- **safety procedures for servicing accumulators**
- **intensifiers**
- **gauges**
- **sensors**
  - pressure
  - flow
  - temperature
  - position
- **switches**
  - pressure
  - temperature
  - limit
- **demonstrate safe charging and repair procedures for accumulators**

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye and hand protection
  - chemical hazards—WHMIS
  - high pressure concerns for skin penetration
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1256.4 **Hydraulic Actuators**

Duration: Total 10 hours Theory 6 hours Practical 4 hours

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:

HDET 5892.01, 5892.02, 5895.03

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to recommend repair procedures for hydraulic actuators following manufacturers' recommended procedures.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

2.4.1 Explain the purpose and fundamentals of hydraulic actuators.

[2/0]

- **displacement**
- **horsepower**
- **flow rate**
- **aeration**
- **pressure and force**
- **cavitation**
- **friction**
- **graphic symbols**
- **contamination and importance of cleanliness**
- **torque**
- **torque rates**
- **rod speed**
- **shaft speed**

2.4.2 Identify the construction features of hydraulic actuators.

[2/0]

- **motors**
  - gear
  - vane
    - balanced
    - unbalanced
  - compensating valves
  - piston
    - variable displacement
    - radial
    - axial
    - bent axis

- **cylinders**
  - single acting
  - double acting
  - series telescoping
  - regenerating

2.4.3 Describe the principles of operation of hydraulic actuators.

[1/0]
- **motors**
  - high speed low torque
  - anti-cavitation check valves
  - low speed high torque
  - gear
  - vane
    - balanced
    - unbalanced
  - piston
  - radial
  - axial
  - bent axis
- **cylinders**
  - single acting
  - double acting
    - differential
    - non differential
    - single rod end
    - double rod end
  - series telescoping

2.4.4 Demonstrate inspection, testing, and diagnostic procedures following manufacturers' recommendations for hydraulic actuators.

[0.5/2]
- **motors**
  - case drain requirements
- **cylinders**
  - by-passing
- **failure analysis of hydraulic motor and cylinder components**

2.4.5 Recommend reconditioning or repairs following manufacturers' for hydraulic actuators.

[0.5/2]
- **outline the recommended procedures to remove and replace hydraulic motors and cylinders**
- **safe depressurization**
  - priming
  - bleeding
  - case drain line
- **disassemble and reassemble hydraulic actuators**

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye, hearing and hand protection
  - high pressure concerns for skin penetration
  - chemical hazards—WHMIS
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1256.5 **Electronically Managed Hydraulic Systems**

Duration: Total 8 hours Theory 6 hours Practical 2 hours

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:

HDET 5892.02, 5895.03,5895.05

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to recommend repairs to electronically managed hydraulic systems following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT:

Upon successful completion, the apprentice is able to:

2.5.1 Explain the purpose and fundamentals of electronically managed hydraulic systems.

[2/0]
- **area networks**
- **data links**
- **twisted pair wiring**
- **solenoids**
- **feedback circuits**
  - control feedback
- **valve mounted ECM's**
- **actuator mounted ECM's**
- **electrically controlled pilot circuits**
- **servo valves**

2.5.2 Identify the construction features of electronically managed hydraulic systems.

[2/0]
- **area networks**
- **data links**
- **twisted pair wiring**
- **solenoids**
- **feedback circuits**
- **valve mounted ECM's**
- **actuator mounted ECM's**
- **electrically controlled pilot circuits**
- **servo valves**
- **electronic displacement control**

2.5.3 Describe the principles of operation of electronically managed hydraulic systems.

[2/0]
- **ECM inputs and outputs**
- **data link communication**
- **ECM logic**
- **control parameters**

- **deadband**
- **hysteresis**
- **proportional control**
- **open loop control circuits**
- **closed loop control circuits**
- **CAN networks**
- **programmable logic control**
- **distributive control**

2.5.4 Demonstrate an electronically managed hydraulic system diagnostic evaluation according to comparison to manufacturers' specifications.

[0/2]
- **calibrations**
- **diagnostic tooling**
  - display menu
- **cycle times**
- **sensor testing**

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye and hand protection
  - high pressure concerns for skin penetration
  - chemical hazards
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1256.6 **Hydraulic System Diagnosis**

Duration: Total 13 hours Theory 6 hours Practical 7 hours

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:

HDET 5895.01, 5895.02, 5895.04, 5895.05, 5895.06, 5895.07, 5895.08, 5895.09, 5895.10

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to diagnose hydraulic systems and recommend repairs following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

2.6.1 Explain the fundamentals of diagnosing hydraulic systems.

[1/0]
- **interpret manufacturers' diagnostic troubleshooting procedures for hydraulic systems**
- **interpret manufacturers' schematics**

2.6.2 Identify primary causes of failures for hydraulic systems

[2/0]
- **cavitation**
- **aeration**
- **contamination**
- **oil starvation**
- **overheating**
- **overloading**
- **mechanical**
- **electrical**

2.6.3 Describe the procedures to inspect and test the hydraulic system.

[2/0]
- **step-by-step procedures of the troubleshooting charts related to hydraulic systems**
  tests
  - flow
  - pressure
  - bypass
  - cycle times

2.6.4 Perform hydraulic system diagnostics following the manufacturers' recommended procedures.

[0/5] - **step-by-step procedures of the troubleshooting charts related to hydraulic systems test for:**
- flow
- pressure
- bypass
- cycle times

2.6.5 Recommend reconditioning or repairs following the manufacturers' recommended procedures.

[1/2] - **demonstrate failure analysis as related to the following components:**
- pumps
- piston
- vane
- gear
- control valves
- pressure
- flow
- directional
- actuators
- linear
- rotary
- conductors
- adapters

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye and hand protection
  - high pressure concerns for skin penetration
  - chemical hazards--WHMIS
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

Number:	**S1257**		
Reportable Subject:	**ENGINE SYSTEMS**		
Duration:	Total 24 hours	Theory 16 hours	Practical 8 hours
Prerequisites:	CVAE Level 2		
Co-requisites:	None		

3.1 Engine Short Block Assembly

5 Total Hours Theory: 5 hours Practical: 0 hours

3.2 Engine Diagnosis

12 Total Hours Theory: 6 hours Practical: 6 hours

3.3 Engine Short Block Reconditioning

7 Total Hours Theory: 5 hours Practical: 2 hours

Evaluation Structure: Assignments related to theory and appropriate application skills.
Proctored final exam.
Periodic quizzes.

Mark Distribution:

Theory Testing	Practical Application Testing
70%	30%

Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:
O.E.M. Equipment Documentation

Recommended Minimum Equipment:

Diesel engines (parent block)	Piston ring installation tool
Precision measuring tools	Piston installation tool
Cylinder protrusion measuring tool	Sleeve puller
Cylinder counterbore measuring tool	Seal removal/ installation tools
Cylinder bore measuring tools	Basic hand tools
Diesel engines (wet sleeves)	Running Equipment or Simulator
Magnetic crack detection equipment	Torque wrenches

S1257.1 **Engine Short Block Assembly**

Duration: Total 5 hours Theory 5 hours Practical 0 hours

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:

HDET 5891.11, 5891.12, 5891.13

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe the testing and servicing procedures of an engine short block assembly following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

3.1.1 Explain the fundamentals of the engine short block components.

[2/0]

- **bore**
- **stroke**
- **engine displacement**
- **stress areas**
- **engine efficiency**
- **calculations**
  - torque rise
- **overview of block types**
  - wet/dry sleeves
  - parent/Enbloc (No liners)
- **anti vibration methods**
- **cooling and lubrication methods**
- **camshaft bearings**

3.1.2 Identify the construction features of the engine short block components.

[2/0]

- **cylinder block**
  - parent/Enbloc
- **liner types**
  - wet
  - dry
- **liner construction materials**
- **crankshaft and bearings construction**
- **thrust bearings**
- **connecting rod to piston attaching methods**
- **designs of connecting rod mating surfaces**
  - cracked rod (fractured)

- **piston features, types and construction materials**
  - forged steel
  - composite steel
  - aluminium
  - articulating
  - cam ground
  - piston cooling methods
  - piston ring types
- **anti-vibration devices**
  - vibration dampers
    - viscous
    - rubber
  - balance shafts
- **covers, seals, and gaskets**
- **fly-wheel types**
- **camshaft bearings**

3.1.3 Describe the principles of operation of the engine short block components.

[1/0]

- **cylinder block**
- **wet versus dry sleeve engines**
- **sleeve materials**
- **crankshaft and bearings construction**
- **thrust bearings**
- **connecting rod to piston attaching methods**
- **designs of connecting rod mating surfaces**
  - cracked rod
- **pistons**
  - one-piece (trunk type)
    - forged steel
    - composite steel
    - aluminum
  - articulating
  - cam ground
  - piston cooling methods
  - piston ring types
- **anti-vibration devices**
  - vibration dampers
    - viscous
    - rubber
    - balance shafts
- **flywheel types**
- **camshaft bearings**

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye, hearing, breathing, and hand protection
  - rotating components
  - wire and grinding wheels
  - cleaning agents
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - system international d'unités (s.i.) to Imperial conversion

S1257.2 **Engine Short Block Diagnosis**

Duration: Total 12 hours Theory 6 hours Practical 6 hours

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:

HDET 5891.11

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to demonstrate the diagnostic procedures used for engines following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

3.2.1 Explain the fundamentals of engine diagnosis.

[3/0] - **identify diagnostic procedures to verify engine performance complaints**
- power loss
- noises
- oil consumption
- exhaust smoke
  - excessive
  - blue
  - white
  - black
- vibrations
- coolant consumption
- external leaks
- overheating
- overcooling
- hard starting
- excessive fuel consumption

3.2.2 Identify engine performance test procedures following manufacturers' recommendations and safe work practices.

[1/2]

- **demonstrate the following using a stall test**
  - fuel pressure
  - torque, power
  - operating temperatures
    - exhaust /intake temperatures
  - intake pressures
  - exhaust pressures
  - crankcase pressures
  - stall speeds
  - electronic monitoring
  - boost pressure

3.2.3 Perform failure analysis following the manufacturers' recommended procedures.

[2/4]

- **Blocks**
  - warpage
  - cracks
  - corrosion
  - wear
- **crankshafts/camshafts**
  - breakage
  - bending
  - lack of lubrication
  - wear/scoring
  - cracks
- **sleeves**
  - erosion
  - corrosion
  - wear/scoring
  - cracks
  - protrusion height
- **pistons, rings, pins, piston cooling devices**
  - wear/scoring
  - cracks
  - overheating
  - seizure
- **connecting rod**
  - bending/twisting
  - bore distortions
  - cracks
  - stretch
  - fastener failures
- **flywheels**
  - distortion
- **anti vibration devices**
  - separation
  - cracks
  - leakage

- **bearings and seals**
  - wear /scoring
  - cracks
  - overheating
  - seizure
- **diagnostic tests to determine root cause failures for:**
  - cooling system components
  - lubrication system components
  - engine oil contamination
  - coolant contamination

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye and hand protection
  - hot coolant and lubricant
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1257.3 **Engine Short Block Reconditioning**

Duration: Total 7 hours Theory 5 hours Practical 2 hours

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:

HDET 5891.11, 5891.12, 5891.13

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe the testing and servicing procedures for engine short block reconditioning following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

3.3.1 Explain the fundamentals of engine short block reconditioning.

[1.5/0]

- **procedures for:**
  - piston pin fits and tolerances, including press fit, burnishing and honing
  - cylinder ridge removal, de-glazing, honing, and boring
  - cylinder sleeve removal, fits, tolerances, and installation
  - cylinder block counter bore and sleeve protrusion
  - precision measuring devices
  - camshaft bearing replacement

3.3.2 Identify the construction features of equipment required for cylinder sleeve reconditioning, removal, and replacement.

[1/0]

- **ridge remover**
- **de-glazer**
- **hone**
- **counter-bore reconditioner**
- **liner puller**

3.3.3 Describe the principles of operation of the equipment for cylinder sleeve reconditioning, removal and replacement.

[1.5/0]

- **cylinder service equipment**
  - ridge removal
  - de-glazing
  - honing
  - sleeve installation
  - counter boring
  - cleaning equipment
  - cleaning solutions
    - material reaction

3.3.4 Demonstrate inspection and testing procedures following manufacturers' recommendations for engine short block components.

[1/2]

- **clean the engine block**
  - oil passages
  - coolant passages
  - post cleaning corrosion protection
  - internal protective coating integrity
- **external surfaces**
- **clean piston and connecting rod assemblies**
  - cleaning agents
- **carbon removal**
- **block distortion and gasket surface checks**
- **crankshaft checks**
  - end play
  - bearing clearance
    - plastigage
- **flywheel run-out**
- **rod side clearance checks**
- **piston ring side clearance and end gap checks**

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye and hand protection
  - rotating hone precautions
  - corrosive chemical risk
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

Number:	**S1258**		
Reportable Subject:	**ELECTRICAL/ELECTRONIC SYSTEMS**		
Duration:	Total 40 hours	Theory 22 hours	Practical 18 hours
Prerequisites:	CVAE Level 2		
Co-requisites:	None		

4.1 Charging Systems

20 Total Hours Theory: 12 hours Practical: 8 hours

4.2 Computerized Management Systems

14 Total Hours Theory: 7 hours Practical: 7 hours

4.3 Electrical Diagnosis

6 Total Hours Theory: 3 hours Practical: 3 hours

Evaluation Structure: Assignments related to theory and appropriate application skills.
Proctored final exam.
Periodic quizzes.

Mark Distribution:

Theory Testing	Practical Application Testing
60%	40%

Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:
O.E.M. Equipment Documentation

Recommended Minimum Equipment:

Heavy duty alternators	Alternator test stand
Heavy duty carbon pile	High Impedance multi-meters
Equipment or simulator with electronic control modules	Electronic service tool (OEM type programming, **not** a generic scan tool) capable of connection to the above tractor

S1258.1 **Charging Systems**

Duration: Total 20 hours Theory 12 hours Practical 8 hours

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:

HDET 5894.01, 5897.07, 5894.08, 5894.09

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to recommend repair of charging systems following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

4.1.1 Explain the purpose and fundamentals of charging system components.

[2/0]

- **current flow**
- **diodes**
- **electromagnetism**
- **voltage induction**
- **inductive reactance of stator**
- **battery conditions as affecting internal resistance**
- **principles of tracing wiring schematics**
- **electrical/electronic symbols**
- **Ohm's law**
- **temperature effects**
- **factors affecting voltage and amperage output**
  - field strength
  - rotor speed
- **inductor reactance**

4.1.2 Identify the types and construction features of charging system components.

[3/0]

- **brush-type alternators**
  - rectifier
  - stator
    - delta
    - wye
  - rotor
    - field winding
    - poles
    - slip rings
  - diode trio
  - brush assembly
  - case
  - bearings and pulleys
- **brushless alternators**
  - stationary field
  - magnetic poles
  - stator
  - rectifier
  - transformer 12/24 volt system
- **voltage regulators**
  - external electronic
  - internal electronic
  - electronic digital

4.1.3 Describe the principles of operation of charging systems.

[5/0]

- **brush-type alternators**
  - rectifier
    - full-bridge
    - half-bridge
  - induction principles
  - electromagnetism
    - induction
    - inductive reactance
  - alternating current
  - three-phase
- **brushless alternators**
- **dual voltage alternator**
  - transformer principle
- **voltage regulator**
  - electronic principles
  - load response

4.1.4 Perform inspection and diagnostic procedures following manufacturers' recommendations for charging systems.

[1/4]

- **visual inspection**
  - belt tension and alignment
  - connections and wiring
  - battery and alternator specifications and application
- **outline recommended charging system testing sequence**
- **battery condition tests**
- **charging circuit resistance voltage drop tests**
- **charging system current and voltage output tests**
- **identify specific charging system faults from test results**
- **alternator bench testing for output current and voltage**
- **voltage regulator bench tests**
- **identify electronic noise suppression devices**

4.1.5 Recommend reconditioning or repair procedures following manufacturers' recommendations for charging systems.

[1/4]

- **verify output capacity to satisfy the specific vehicle electrical load specifications**
- **perform adjusting procedures of alternator drive belt tension and alignment**
- **remove and replace an alternator and verify operation**

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye, hearing, breathing, and hand protection
  - accidental grounding of rings, jewellery, tools
  - equipment connection precautions
  - open circuit voltage precautions
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1258.2 **Computerized Management Systems**

Duration: Total 14 hours Theory 7 hours Practical 7 hours

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:

HDET 5894.01, 5894.10, 5894.11, 5894.12

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to test and computerized management systems following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

4.2.1 Explain the fundamentals of Electronic Control Modules computerized management systems

[1.5/0]

- **analog/digital signals**
- **binary systems**
- **logic gates**
- **multiplexing**
  - data bus protocols
  - ISO and Non ISO protocols
- **fibre optics**

4.2.2 Identify the types and construction features of computerized management systems

[1.5/0]

- **input devices**
  - sensors
  - switches
  - data links
- **central processing unit**
- **data storage**
  - Random Access Memory (RAM)
  - Read Only Memory (ROM)
  - Programmable Read Only memory (PROM)
  - Erasable Programmable Read Only Memory (EPROM)
  - Electronically Erasable Programmable Read Only Memory (EEPROM)
- **output circuits**
  - reference voltage
  - relays
  - solenoids
  - power modules

4.2.3 Describe the principles of operation of computerized management systems.

[3/0]
- **analog to digital converters**
- **signal filtration**
- **central processing unit (CPU)**
- **processing cycle**
- **logic sequencing**
- **data storage**
- **output circuits**

4.2.4 Perform inspection and diagnostic procedures for computerized management systems following manufacturers' recommendations.

[0.5/7]
- **code identification**
  - FMI (failure mode Identification)
  - DTC (diagnostic trouble code)
  - Audit trails
  - Clearing codes
- **demonstrate (EST) electronic service tool diagnostic tests**
- **electronic service tool diagnostic tests**
  - **reprogramming ECM**
- **diagnostic codes extraction**
- **demonstrate sensor input tests**
- **demonstrate output device tests**

4.2.5 Recommend reconditioning or repairs following manufacturers' recommendations for computerized management systems.

[0.5/0]
- **identify static electricity and induction interference prevention procedures**
- **outline (ECM) electronic control module replacement procedures**
  - reprogramming ECM
  - extracting data from old ECM

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye and hand protection
  - electrostatic discharge
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1258.3 **Electrical Diagnosis**

Duration: Total 6 hours Theory 3 hours Practical 3 hours

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:

HDET 5894.01, 5894.02, 5894.03, 5894.04, 5894.07, 5894.10

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to test and diagnose electrical circuit defects following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

4.3.1 Explain the fundamentals of electrical circuit diagnosis.

[1/0]
- **visual inspection**
  - corrosion
  - overheating
  - broken wires
  - odour
- **verify meter integrity**
  - accuracy
  - meter connections
  - calibration
- **schematic and circuit relationships**

4.3.2 Identify types of circuit failures.

[1/0]
- **opens**
- **shorts**
- **unintentional grounds**
- **high resistance**

4.3.3 Perform testing and diagnostic procedures following manufacturers' recommendations for electrical circuit failures.

[1/3]
- **visual circuit test procedures**
- **meter circuit testing procedures**
- **electrical circuit diagnostic procedures**
  - test light vs. multi-meter for diagnosing

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye, hearing, breathing, and face protection
  - battery gas precautions
  - explosion precautions
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

Number:	**S1259**		
Reportable Subject:	**FUEL SYSTEMS**		
Duration:	Total 40 hours	Theory 25 hours	Practical 15 hours
Prerequisites:	CVAE Level 2		
Co-requisites:	None		

5.1 Diesel Fuel Injection Partial-Authority Engine Management Systems

13 Total Hours Theory: 9 hours Practical: 4 hours

5.2 Diesel Fuel Injection Full-Authority Engine Management Systems

23 Total Hours Theory: 14 hours Practical: 9 hours

5.3 Diesel Engine Emission Systems

4 Total Hours Theory: 2 hours Practical: 2 hours

Evaluation Structure: Assignments related to theory and appropriate application skills.
Proctored final exam.
Periodic quizzes.

Mark Distribution:

Theory Testing	Practical Application Testing
60%	40%

Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:
O.E.M. Equipment Documentation

Recommended Minimum Equipment:

Equipment with partial authority fuel management system	Electronic service tool to connect to the above pieces of equipment (OEM type)
Equipment with full authority fuel management system	Fuel system components

S1259.1 **Diesel Fuel Injection Partial-Authority Engine Management Systems**

Duration: Total 13 hours Theory 9 hours Practical 4 hours

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:

HDET 5891.14, 5891.15, 5891.16, 5892.01, 5892.02, 5892.03, 5892.04, 5892.05, 5892.06, 5892.07, 5892.08, 5892.09

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to recommend the testing and servicing procedures for diesel fuel injection partial-authority engine management systems following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

5.1.1 Explain the fundamentals of partial-authority, electronic diesel engine management systems.

[1/0]

- **purpose, function, types, styles, and application**
  - inline system electronic engine management controls
  - distributor systems
- **fundamentals enhancement**
  - transducers
  - thermister
  - negative/positive coefficient
  - potentiometers
  - magnetic
  - engine timing requirements
    - static
    - electronic advance
- **overview of inline and distributor pump systems adapted electronic engine controls**

5.1.2 Identify the construction features of partial-authority, electronic diesel engine management systems and components.

[3/0]

- **inline system**
  - rack actuators
  - rack position sensors
  - brushless torque motors (BTM)
  - transducers
- **distributor systems**
  - inlet metering
  - sleeve metering
  - timing controls
  - hydraulic head controls
- **electronic controls**
  - servo controls
  - pulse wheels
  - linear magnet
  - variable timing control
  - electronic governor
  - hall effect sensor
- **hydraulic injectors**
  - hydraulic nozzle holders
  - pintle nozzles
  - multi-orifii nozzles
- **high pressure pipes**
- **leak- off lines**
- **fuel manifolds**

5.1.3 Describe the principles of operation of partial-authority, electronic diesel engine management systems and components.

[3/0]

- **inline system**
  - rack actuators
  - rack position sensors
  - brushless torque motors (BTM)
  - transducers
- **distributor systems**
  - inlet metering
  - sleeve metering
  - timing controls
  - hydraulic head controls
- **electric controls**
  - servo controls
  - pulse wheels
  - linear magnet
  - variable timing control
  - electronic governor
  - hall effect sensor

- **hydraulic injectors**
  - hydraulic nozzle holders
  - pintle nozzles
  - multi-orifii nozzles
- **high pressure pipes**
- **leak- off lines**
- **fuel manifolds**

5.1.4 Demonstrate-inspection, testing and diagnostic procedures following manufacturers' recommendations for partial-authority, electronic diesel engine management systems and components.

[1/4]
- **identify components and their location**
- **recommended tests on system input sensors and output devices**
- **reader/programmer/personal computer software diagnostics on the inline systems**

5.1.5 Recommend reconditioning or repair procedures following manufacturers' recommendations for partial-authority electronic diesel engine management systems and components.

[1/0]
- **outline the recommended repair procedures for fuel injection systems**
  - electronic connections
  - wiring harness
  - connector repairs
  - circuit resistance tests
  - pump replacement

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye and hand protection
  - proper polarity connections
  - high pressure
  - rotating shafts, belts and pulleys
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1259.2 **Diesel Fuel Injection Full-Authority Engine Management Systems**

Duration: Total 23 hours Theory 14 hours Practical 9 hours

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:

HDET 5892.06, 5892.07, 5892.08, 5892.09

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to recommend repairs for diesel fuel injection full-authority engine management systems following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

5.2.1 Explain the fundamentals of diesel fuel injection full-authority engine management systems.

[1/0]
- **applications**
- **types**
- **strategy**
- **emission legislation**

5.2.2 Identify the construction features of full-authority electronic control diesel fuel injection systems and components.

[6/0]

- **sensors**
  - speed
    - crankshaft
    - camshaft
    - turbocharger
    - driveline
  - pressure
    - engine oil
    - exhaust
    - intake manifold
    - atmospheric
    - fuel
    - injection actuation
    - cylinder
    - boost
  - temperature
    - fuel
    - engine oil
    - exhaust
    - DPF
    - coolant
    - ambient air
  - position
    - throttle
    - crankshaft
    - camshaft
    - EGR (exhaust gas recirculation)
    - VGT (variable geometry turbocharger)
- **electronic unit injectors**
  - pulse width
  - poppet control valve
  - circuit protection
- **hydraulic electronic unit injector (HEUI)**
  - high pressure pump
  - pressure regulator
  - pressure sensor
  - unit injector
  - oil reservoir
- **high pressure common rail**
  - high pressure pump
  - pressure regulator
  - pressure sensor
  - time-pressure (PT) injector
- **injector drivers**

- **status switches**
  - cruise control
  - clutch and brake
  - exhaust brake
  - power take-off
  - air brake
- **electronic control module**
  - protection shut down
  - limp home mode
  - backup microprocessor

5.2.3 Describe the principles of operation of full-authority electronic control diesel fuel injection systems and components.

[6/0]

- **sensors**
  - speed
    - crankshaft
    - camshaft
    - turbocharger
    - driveline
  - pressure
    - engine oil
    - exhaust
    - intake manifold
    - atmospheric
    - fuel
    - injection actuation
    - cylinder
    - boost
  - temperature
    - fuel
    - engine oil
    - exhaust
    - DPF
    - coolant
    - ambient air
  - position
    - throttle
    - crankshaft
    - camshaft
    - EGR (exhaust gas recirculation)
    - VGT (variable geometry turbocharger)
- **electronic unit injectors**
  - pulse width
  - pulse profile
  - poppet control valve
  - effective stroke control
  - time control

- **injector drivers**
  - switching characteristics
  - spiked actuation
  - injector response time
- **hydraulic electronic unit injector (HEUI)**
  - high pressure pump
  - pressure regulator
  - pressure sensor
  - unit injector
  - oil reservoir
- **high pressure common rail**
  - high pressure pump
  - pressure regulator
  - pressure sensor
  - time-pressure (TP) injector
- **electronic control module**
  - protection shut down
  - limp home mode
  - backup microprocessor
  - injector driver
  - cooling
  - power de-rate mode
  - data management
  - programming
  - power bulge

5.2.4 Perform inspection and diagnostic procedures following manufacturers' recommendations for full-authority electronically controlled diesel fuel injection systems.

[0/9]
- **identify components and locations**
- **diagnostic techniques**
- **interpret electronic flow charts**
- **demonstrate the application of the electronic service tool (EST) and personal computer**
- **demonstrate reprogramming and uploading processes using a electronic service tool (EST)**
- **confirm electronic diagnosis with multi-meter testing**

5.2.5 Recommend reconditioning or repair procedures following manufacturers' recommendations for full-authority engine management systems.

[1/0]
- **describe connector seal assembly procedures**
- **outline checking procedures for electrical ground connection integrity**
- **outline boost starting procedures**
  - battery
  - charger
  - unit to unit

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye protection, spontaneous combustion
  - CSA approved equipment for emptying tanks and storing fuel
  - priming and starting procedures, starting fluids applications
  - hazards of solvents
  - high pressure fuel lines
  - emergency shutdown procedures
  - high pressure injector spray precautions
  - high voltage
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1259.3 **Diesel Engine Emission Systems**

Duration: Total 4 hours Theory 2 hours Practical 2 hours

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:

HDET 5893.01, 5893.08, 5893.09, 5893.10

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to interpret the exhaust emissions produced by diesel engines following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

5.3.1 Explain the fundamentals of diesel engine emission systems.

[2/0]

- **properties**
  - carbon monoxide
  - hydrocarbons
  - oxides of nitrogen
  - particulates
  - carbon dioxide
  - sulphur dioxide
  - aldehydes
- **catalysts**
  - **oxidation**
- **emission standards**
- **federal regulations**
- **provincial regulations**
- **aneroids**
- **altitude compensators**
- **sensors on emission controls**

5.3.2 Demonstrate testing procedures following manufacturers' recommendations for diesel engine emission systems.

[0/2]

- **inspecting emission control devices**
- **exhaust smoke analysis**
  - light extinction methods
  - opacity meter
  - filtration/colour code method
- **exhaust gas analysis**
  - four gas analysis

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye protection, spontaneous combustion
  - CSA approved equipment for emptying tanks and storing fuel
  - priming and starting procedures, starting fluids applications
  - hazards of solvents
  - high pressure fuel lines
  - emergency shutdown procedures
  - high pressure injector spray precautions
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

Number:	**S1260**		
Reportable Subject:	**Drive Train Systems**		
Duration:	Total 32 hours	Theory 16 hours	Practical 16 hours
Prerequisites:	CVAE Level 2		
Co-requisites:	None		

6.1 Torque Converters, Fluid Couplings, and Hydraulic Retarders

12 Total Hours Theory: 6 hours Practical: 6 hours

6.2 Hydrostatic Drive Systems

20 Total Hours Theory: 10 hours Practical: 10 hours

Evaluation Structure: Assignments related to theory and appropriate application skills.
Proctored final exam.
Periodic quizzes.

Mark Distribution:

Theory Testing	Practical Application Testing
60%	40%

Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:
O.E.M. Equipment Documentation

Recommended Minimum Equipment:

Precision measuring tools	Basic hand tools
Appropriate pressure test equipment	Equipment with powershift transmission and torque converters
Hydraulic Retarder Components	Fluid coupling components
Hydrostatic pumps and drive motors	Torque converter components

S1260.1 **Torque Converters, Fluid Couplings, and Hydraulic Retarders**

Duration: Total 12 hours Theory 6 hours Practical 6 hours

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:

HDET 5896.0, 5896.01, 5896.08, 5896.09, 5896.10

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to recommend repairs for torque converters, fluid couplings, and hydraulic retarders following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

6.1.1 Explain the purpose and fundamentals of torque converters, fluid couplings, and hydraulic retarders.

[2/0]

- **torque converters**
  - static and dynamic friction
  - torque multiplication
  - centrifugal force
  - centripetal force
  - vortex and rotary flow
  - kinetic energy
- **hydrodynamic drive**
- **multiplication phase**
- **coupling phase**
- **hydraulic retarders**

6.1.2 Identify the construction features of torque converters, fluid couplings, and hydraulic retarders.

[2/0]

- **torque converters**
  - pumps
  - impeller
  - stator
    - fixed
    - rotating
  - overrunning clutch
  - flywheel
  - lock-up device
- **fluid couplings**
  - impeller
  - turbine
  - flywheel

- **hydraulic retarders**
  - rotor and housing
  - control valve

6.1.3 Describe the principles of operation of torque converters, fluid couplings, and hydraulic retarders.

[1/1]

- **torque converters**
  - pump
  - impeller
  - stator
    - fixed
    - rotating
- **overrunning clutch**
- **flywheel**
- **lock-up**
- **fluid couplings**
  - impeller
  - turbine
  - flywheel
- **oil flow action**
- **hydraulic retarders**
  - rotor and housing
  - control valve

6.1.4 Perform inspection, testing, and diagnostic procedures following manufacturers' recommendations for torque converters, fluid couplings, and hydraulic retarders.

[0/4]

- **oil level condition check**
- **demonstrate oil leak tests**
- **converter end play check**
- **demonstrate converter:**
  - stall tests
  - relief valve tests
  - performance tests
- **component failure analysis**

6.1.5 Recommend reconditioning or repair procedures following manufacturers' recommendations for torque converters, fluid couplings, and hydraulic retarders.

[1/1]

- **show examples of component failures for:**
  - pumps
  - impeller
  - stator
  - overrunning clutch
  - lock-up devices
  - rotors
  - control valves
- **identify contamination protection procedures**
- **outline the recommended oil change procedures**

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye and hand protection
  - precision measuring tool precautions
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1260.2 **Hydrostatic Drive Systems**

Duration: Total 20 hours Theory 10 hours Practical 10 hours

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:

HDET 5896.0, 5896.17, 5896.18, 5896.19

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to recommend repairs for hydrostatic drive systems following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

6.2.1 Explain the purpose and fundamentals of hydrostatic drives.

[2/0]

- **application**
  - traction drives
  - non-traction drives
- **types**
  - open loop circuits
  - closed loop circuits
- **fundamentals**
  - lubricant types
  - hydraulic pressures and output force
  - coolers and circuits
- **torque multiplication**
- **hydrodynamic versus hydrostatic drive systems**
- **charge pump**
- **charge pump circuits**

6.2.2 Identify the types and construction features of hydrostatic drives.

[2/0]

- **hydrostatic drives**
  - variable displacement pumps
  - fixed displacement pumps
  - variable displacement motors
  - fixed displacement motors
- **controls**
  - flow limiting
  - flow dividing
  - manual displacement control valves
  - electronic displacement control valves
  - hydraulic displacement control valves
- **charge pump**

- **charge pump circuits**
- **coolers and circuits**

6.2.3 Describe the principles of operation of hydrostatic drives.

[2/0]

- **hydrostatic drives**
  - variable displacement pumps
  - variable displacement motors
  - fixed displacement pumps
  - fixed displacement motors
- **operation of drive systems in neutral, forward, and reverse**
- **controls**
  - flow limiting
  - flow dividing
  - manual displacement control valves
  - electronic displacement control valves
  - hydraulic displacement control valves
- **charge pumps**
- **charge pump circuits**
- **coolers and circuits**

6.2.4 Perform the inspection, testing, and diagnostic procedures following manufacturers' recommendations on hydrostatic drives.

[2/8]

- **test pressures of various hydrostatic drive systems**
- **examine and measure hydrostatic drive motor and pump components**
- **verify recommended operating functions of hydrostatic drive controls**
- **outline methods and procedures to diagnose and determine causes of abnormal noises, directional control problems, and malfunctions in hydrostatic drive systems**
- **verify recommended operating temperatures of hydrostatic drives**
  - cooler restrictions
  - filter restrictions

6.2.5 Recommend reconditioning or repairs following manufacturers' recommendations for hydrostatic drives.

[2/2]
- **demonstrate field adjustments for hydrostatic drive systems**
- **explain the recommended oil levels and grade**
- **outline recommended removal and replacement procedures for hydrostatic motors, pumps, and coolers**
- **demonstrate the disassembly and reassembly procedures for hydrostatic drive systems**

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye and hand protection
  - high pressure concerns for skin penetration
  - chemical hazards – WHIMIS
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

Number: **S1261**

Reportable Subject: **BRAKE, TRACK AND SUSPENSION SYSTEMS**

Duration: Total 32 hours Theory 18 hours Practical 14 hours

Prerequisites: CVAE Level 2

Co-requisites: None

7.1 Hydraulic Brake Systems

17 Total Hours Theory: 9 hours Practical: 8 hours

7.2 Track-Type Undercarriages

11 Total Hours Theory: 6 hours Practical: 5 hours

7.3 Suspension Systems

4 Total Hours Theory: 3 hours Practical: 1 hour

Evaluation Structure: Assignments related to theory and appropriate application skills.
Proctored final exam.
Periodic quizzes.

Mark Distribution:

Theory Testing	Practical Application Testing
70%	30%

Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:
O.E.M. Equipment Documentation

Recommended Minimum Equipment:

Equipment with hydraulic brake system	Precision measuring tools
Hydraulic brake components	Torque wrench
Equipment with tracks	Suspension system components
Track components	Wheel end brake assemblies (Inboard and Outboard)
Equipment with suspension systems	Brake system pressure gauge set

S1261.1 **Hydraulic Brake Systems**

Duration: Total 17 hours Theory 9 hours Practical 8 hours

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:

HDET 5891.01, 5891.02, 5891.03, 5891.04

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to perform repairs following manufacturers' recommendations and safe work practices of hydraulic brake systems.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

7.1.1 Explain the fundamentals of hydraulic brake systems.

[2/0]

- **hydraulic brake schematics**
  - flow tracing
  - component location and identification
- **wheel ends**
  - multi-disc
  - inboard/outboard
  - spring applied hydraulic release
  - hydraulic applied spring release
  - external disc brakes
  - brake components
  - interpretation of brake schematics

7.1.2 Identify the construction, composition features, types, styles, and application of hydraulic brake systems.

[3/0]

- **system components**
  - charge control valves
  - accumulators
  - shuttle valves
  - directional valves
  - flow valves
  - sequence valves
  - pumps
- **wheel components**
  - pistons
  - seals
  - springs
  - disc/plates
  - calipers

7.1.3 Describe the principles of operation of hydraulic brake systems.

[2/0]

- **system components**
  - charge control valves
  - accumulators
  - shuttle valves
  - directional valves
  - flow valves
  - sequence valves
  - pumps
- **wheel end**
  - pistons
  - seals
  - springs
  - disc/plates
  - calipers

7.1.4 Perform inspection, testing, and diagnostic procedures following manufacturers' recommendations and safe work practices on hydraulic brake systems.

[0/4]

- **check and adjust charge pressures (kick-in/out)**
- **check and adjust accumulator charge pressure**
- **interpret hydraulic brake schematics**
- **interpret potential malfunctions using manufacturers' diagnostic troubleshooting procedures**
- **interpret test results and performance problems**
  - noises
  - drag or lockup
  - vibrations
  - imbalance
- **check and adjust wheel end brake pressure**
- **check and adjust wheel end lubrication and cooling pressure**

7.1.5 Recommend reconditioning or repairs following manufacturers recommendations to hydraulic brake systems.

[2/4]

- **disassemble and assemble wheel end assembly**
  - spring applied, hydraulic release
    - safety precautions, stored energy of spring applied brakes
  - hydraulic applied, spring release
  - external dry disc

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye and skin protection
  - equipment lifting and supports
  - high pressure concerns
  - pinch points (articulating)
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1261.2 **Track-Type Undercarriages**

Duration: Total 11 hours Theory 6 hours Practical 5 hours

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:
HDET 5904.05, 5904.06, 5904.07

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to recommend the repair procedures for track-type undercarriages following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

7.2.1 Explain the fundamentals of track-type undercarriages.

[1.5/0]
- **traction**
- **soil compaction**
- **vehicle stability**
- **vehicle application**
- **chain terminology**
  - standard track
  - center ride track (e.g. Cat System One)
- **sprocket terminology**

7.2.2 Identify the composition and construction features of track-type undercarriage components.

[2/0]
- **track frames**
  - oscillating
  - non-oscillating
  - conventional style
  - hi-track style
- **track adjustment systems**
  - grease piston
  - hydraulic cylinder
- **Idlers**
  - recoil assemblies
- **drive sprockets**
  - segments
  - one piece
- **track chains**
  - sealed and lubricated
  - center ride (e.g. Cat System One)
- **pads**

- **guards and shields**
- **track tension**
- **track**
  - pins and bushings
  - reusability limits
- **rollers**
  - single flange
  - double flange
- **undercarriage hardware**
  - types and styles
  - reusability guidelines

7.2.3 Describe the principles of operation of track-type undercarriages.

[2/0]

- **track frames**
  - oscillating
  - non-oscillating
  - conventional style
  - hi-track style
- **track adjustment systems**
- **idlers**
- **drive sprockets**
  - segments
  - one piece
- **track chains**
  - sealed and lubricated
  - center ride
- **pads**
- **guards and shields**
- **track tension**
- **track**
  - pins and bushings
  - reusability limits
- **rollers**
  - single flange
  - double flange
- **undercarriage hardware**
  - types and styles
  - reusability guidelines
- **track alignment**
  - idler
  - track rollers
  - frame
  - sprockets

7.2.4 Perform inspection, testing, and diagnostic procedures following manufacturers' recommendations for track-type undercarriages.

[0/3]

- **wear measurements and diagnose causes of failures for:**
  - track frames
    - oscillating
    - non-oscillating
    - conventional style
    - hi-track style
  - idlers
  - drive sprockets
    - segments
    - one piece
  - track chains
  - pads
  - guards and shields
  - track tension
  - sealed and lubricated tracks
  - track
    - pins and bushings
    - reusability limits
    - alignment
  - rollers
    - single flange
    - double flange
    - carrier
- **identify track adjustment systems**
- **identify undercarriage hardware reusability guidelines**

7.2.5 Recommend reconditioning and repair procedures following manufacturers' recommendations for track-type undercarriages.

[0.5/2]

- **identify removal and replacement procedures for:**
  - track frames
    - oscillating
    - non-oscillating
    - **conventional style**
    - hi-track style (Hi-drive)
  - idlers
  - drive sprockets
    - segments
    - one piece
  - track chains
  - pads
  - guards and shields
  - track tension
  - sealed and lubricated tracks
  - track
    - pins and bushings
    - reusability limits
    - alignment
  - rollers
    - single flange
    - double flange
    - carrier
  - undercarriage hardware
- **perform a demonstration of track alignment and adjustment**
  - idler
  - track rollers
  - frame
  - sprockets

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye and skin protection
  - control of hazardous materials/solvents
  - ventilation of work areas
  - lifting/hoisting procedures
  - fire hazard prevention
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1261.3 **Suspension Systems**

Duration: Total 4 hours Theory 3 hours Practical 1 hour

Prerequisites: CVAE Level 2

Cross-Reference to Training Standard:

HDET 5891.01, 5891.02, 5891.03, 5891.04

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to perform repairs following manufacturers' recommendations and safe work practices of suspension systems.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

7.3.1 Explain the fundamentals of suspension systems.

[0.5/0] - **suspension and machine interaction**
- component location and identification
- interpretation of suspension schematics

7.3.2 Identify the construction, composition features, types, styles, and application of suspension systems.

[1.5/0] - **system components**
- ride control
- spring
- hydraulic
- pneumatic
- mechanical
- walking beam
- accumulators
- pumps
- suspension cylinders
- valves
- rubber blocks
- linkages

7.3.3 Describe the principles of operation of suspension systems.

[1/0]

- **system components**
  - ride control
  - spring
  - hydraulic
  - pneumatic
  - mechanical
  - walking beam
  - accumulators
  - valves
  - pumps
  - suspension cylinders
  - rubbers blocks
  - linkages

7.3.4 Outline inspection, testing, and diagnostic procedures following manufacturers' recommendations and safe work practices on suspension systems.

[0/1]

- **adjust suspension systems**
- **ride control operation**
- **adjust accumulator charge pressure**

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye and skin protection
  - control of hazardous materials/solvents
  - ventilation of work areas
  - lifting/hoisting procedures
  - fire hazard prevention
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

Acronyms:

This listing identifies acronyms found in the following motive power curriculum documents:

Level 1 – Commercial Vehicles and Equipment (Common Core)
Level 2 – Commercial Vehicles and Equipment (Common Core)
Level 3 – Agricultural Equipment Technician
Level 3 – Heavy Duty Equipment Technician
Level 2 – Powered Lift Truck Technician
Level 3 – Powered Lift Truck Technician
Level 2 – Truck and Coach Technician
Level 3 – Truck and Coach Technician

A

ABS	anti-lock braking system
AC	alternating current
A/C	air conditioning
AET	Agricultural Equipment Technician
AFC	air fuel control
AGM	absorbed glass mat
API	American Petroleum Institute
ANSI	American National Standards Institute
ATA	American Trucking Association
ATC	automatic traction control
AVR	amp, volt, ohmmeter
AWG	American Wire Gauge
AWS	American Welding Society

B

BCM	body control module
BSP	British Standard Pipe
BTM	brushless torque motor

C

CB	citizen band
CDI	capacitor discharge ignition
CD-ROM	compact disc read only memory
CFC	chlorofluorocarbons
CI	compression ignited
CMVSS	Canadian Motor Vehicle Safety Standard
CNG	compressed natural gas
CPU	central processing unit
CSA	Canadian Standards Association
CVSA	Canadian Vehicle Standards Association
CWS	collision warning systems

D

DC	direct current
DDC	Detroit Diesel Corporation
DFF	direct fuel feed

DIN	Deutsche Institute fur Normung (German Standards Institute)
DMM	digital multimeter
DOS	Disk Operating System
DOT	Department of Transportation
DPF	diesel particulate filter

E

ECM	electronic control module
ECU	electronic control unit
EPROM	erasable programmable read only memory
EEPROM	electronically erasable programmable read only memory
EG	ethylene glycol
EGR	exhaust gas recirculation
ELC	extended life coolant
EPA	Environmental Protection Act
EST	electronic service tool
EUI	electronic unit injector
EUP	electronic unit pump

F

FHSL	Federal Health and Safety Legislation
FMIs	fault mode indicators
FMVSS	Federal Motor Vehicle Safety Standards
FOPS	Falling Object Protection System
FRP	fiberglass reinforced plywood

G

GCWR	Gross Combined Weight Rating
GFI	gasoline fuel injection
GPS	global positioning satellite
GVW	Gross Vehicle Weight
GVWR	Gross Vehicle Weight Rating

H

HC	hydrocarbon
HDET	Heavy Duty Equipment Technician
HEUI	hydraulically actuated electronic unit injector
HCFC	hydrochlorofluorocarbons
HFC	hydrofluorocarbons
HPI-TP	high pressure injector-time pressure (Cummins)
HVAC	heating, ventilation and air conditioning

I

ID	inside diameter
ISO	International Standards Organization

J

JIC	Joint Industry Conference
JIS	Japanese Industrial Standard
JIT	just in time

K

KPI	king pin inclination

L

LED	light emitting diode
LPG	liquid petroleum gas
LVD	low voltage disconnect

M

MAP	manifold absolute pressure
MIDs	message identifiers
MIG	metal inert gas
MSDS	material safety data sheet
MUI	mechanical unit injector
MVSA	Motor Vehicle Safety Act (Canadian)

N

N/A	not applicable
NOP	nozzle opening pressure
NPN	negative positive negative semi-conductor
NPT	National Pipe Thread
NV-RAM	non-volatile random access memory

O

OD	outside diameter
ODP	ozone depletion prevention
OEM	original equipment manufacturer
OHSA	Occupational Health and Safety Act
OOS	out of service criteria
OPS	operator protection system
ORB	o-ring boss
ORFS	o-ring face seal

P

PC	personal computer
PCV	positive crankcase ventilation
PFI	port fuel injection
PG	propylene glycol
PHSL	Provincial Health and Safety Legislation
PIDs	parameter identifiers
PLTT	Powered Lift Truck Technician
PNP	positive negative positive semi-conductor
PROM	programmable read only memory
PT	pressure time
PTA	pressure time (injector) A series
PTG-AFC	pressure time governor/air fuel control
PTD	pressure time (injector) B series
PTG	pressure time governor (control pump)
PTO	power take-off
PWM	pulse width modulation

R

RAM	random access memory
RBM	resist bend moment
ROM	read only memory
ROPS	roll over protection system
R.P.	recommended practices
RPM	revolutions per minute

S

SAE	Society of Automotive Engineers
SALT	sealed and lubricated tracks
SCA	supplemental coolant additives
SI	spark ignited
s.i.	Système International d'Unités
SIDs	sub-system identifiers
SMAW	shielded metal arc welding
SRS	supplemental restraint systems
STC	step timing control

T

TBI	throttle body injection
TCT	Truck and Coach Technician
TDS	total dissolved solids
TP	time/pressure injector
TPS	throttle position sensor
TQM	total quality management
TMC	Technical and Maintenance Council

V

VCO	valve closes orifice
VIN	vehicle identification number

W

WHMIS	Workplace Hazardous Materials Information System
WIF	water in fuel sensors

Glossary:

This glossary provides definitions of terms found in the following motive power curriculum documents:

Level 1 – Commercial Vehicles and Equipment (Common Core)
Level 2 – Commercial Vehicles and Equipment (Common Core)
Level 3 – Agricultural Equipment Technician
Level 3 – Heavy Duty Equipment Technician
Level 2 – Powered Lift Truck Technician
Level 3 – Powered Lift Truck Technician
Level 2 – Truck and Coach Technician
Level 3 – Truck and Coach Technician

A

ABS	Anti-lock braking system. Electronically controlled brakes that monitor vehicle wheel speeds and manage application forces to prevent wheel lock-up.
AC	See *alternating current.*
A/C	Air conditioning.
accumulator	A cylinder or device used to store pressure, can contain a diaphragm and pneumatic pressure. Used in hydraulic systems.
Ackermann Angle	Angle between the planes of the steered wheels of a vehicle with zero steering angle; a measure of toe-in or toe-out.
acronym	A word formed by the initial letters of other words.
active codes	An electronically monitored system circuit, condition, or component that is malfunctioning and logs an ECM code, which may be displayed or read using an EST.
actuator	Any output device controlled by a computer. Also used in hydraulics as an output device such as a linear or rotary device (cylinder or motor).
aeration	The mixing of gas with a liquid, usually air with oil, fuel, or coolant.
AFC	Air/fuel control.
AFC (Cummins)	A circuit that senses turbo boost sensing and is part of the fuel management components on a Cummins PTC-AFC pump.
AFR	See *air/fuel ratio.*
air/fuel ratio	The mass ratio of an air-to-fuel mixture; also AFR.
air-to-air aftercooler	Heat exchanger that cools the intake air after the turbocharger before going to the intake manifold, by using ambient air.
alcohol	Any of a group of distillate hydrocarbon liquids containing at least one hydroxyl group; sometimes referred to as oxygenates.
aldehydes	A class of chemical compounds having the general formula RCHO, where R is an alkyl (aliphatic) or aryl (aromatic) radical (SAE J1213 NOV82).
alloy	The mixing of a molten base metal with metallic or non-metallic elements to alter the metallurgical characteristics.
alternating current	Electric current that reverses cyclically due to reversal of

	polarity at the voltage source; AC.
altitude-pressure compensator	Any sensor or device that automatically compensates for changes in altitude.
Amboid gear	A bevel gear crown and pinion assembly where the axes are at right angles but the pinion is on a higher plane than the crown.
ANSI	The American National Standards Institute.
American Society for Testing Materials (ASTM)	Agency that sets industry standards and regulations, including those for fuel.
ammeter	Instrument for measuring current flow.
ampere (A)	The unit of measurement for the flow of electric current. An ampere is defined as the amount of current that one volt can send through one ohm of resistance.
analog	The use of physical variables, such as voltage or length, to represent values.
anaerobic sealant	Paste-like sealants that cure (harden) without exposure to air.
aneroid	A device used to sense light pressure conditions. The term is used to describe manifold boost sensors that limit fueling until there is sufficient boost air to combust it and usually consists of a diaphragm, spring, and fuel-limiting mechanism.
antifreeze	A liquid solution added to water to blend the engine coolant solution that raises the boiling point and lowers the freezing point. Ethylene glycol (EG), propylene glycol (PG), and extended life coolants (ELC) are currently used.
antifriction bearing	A bearing that uses balls or rollers between a journal and a bearing surface to decrease friction.
API	The American Petroleum Institute.
application software	Programs that direct computer processing operations.
Apprentice program	Any educational program designed to teach a trade through a combination of on-the-job training and classroom study.
Apprentice technician	A beginner who is learning under the direction of one or more experienced certified technicians.
Aqueous Solution	a solution in water, eg. a homogeneous mixture of two or more substances; frequently (but not necessarily) a liquid solution; "he used a solution of peroxide and water"
Aqueous Urea Injection	Is a system that is designed for reducing NOx (Nitrous Oxide) emissions formed in the presence of high combustion temperatures in internal combustion diesel engines. By injecting urea in the exhaust stream, it causes the NOx to break down into nitrogen and oxygen.
arcing	Bearing or gear failure caused by electric arcing.
articulating piston	A two-piece piston with separate crown and skirt assemblies, linked by the piston wrist pin and afforded a degree of independent movement. The wrist pin is usually full floating or bolted directly to the connecting rod, in which case it is known as a *crosshead piston.*
ASTM	American Society for Testing Materials. Standards rating organization that classifies materials generally and all fuels. American Trucking Association. Organization with a broad

ATA	spectrum of representation responsible for setting standards in the U.S. trucking industry.
ATA data link	An SAE/ATA standard J1584/J1708/J1939, 6-pin Deutsche connector currently used by all truck and truck engine OEMs to access the on-board ECMs.
ATAAC	Air-to-air charge air cooling.
ATDC	After top dead centre.
atom	The smallest part of a chemical element that can take part in a chemical reaction; composed of electrons, protons, and neutrons.
atomization	The process of breaking liquid fuel into small droplets by pumping it at a high pressure through a minute flow area.
atomized droplets	The liquid droplets emitted from an injector nozzle.
audit trail	A means of electronically tracking electronically monitored problems in an engine management system. May be discreet, that is, not read by some diagnostic ESTs and programs; also known as *tattletale*.

B

backfire	Ignition/combustion of the fuel in an oxy-acetylene torch in the torch tip causing a popping and squealing noise.
backlash	The clearance or "play" between two parts, such as the teeth of two gears.
battery	A device containing one or more cells that produces electricity through electrochemical action.
battery capacity	The amount of current a battery is capable of delivering.
battery charging	The process of restoring a battery's charge by passing current through it in a reverse direction (positive to negative).
battery plate	Battery components made of lead peroxide in sponge form and porous lead.
battery rating	Standardized measurement of a battery's ability to deliver an acceptable level of energy under specified conditions. Standards established by the battery council international (BCI).
baud	Times per second that a data communications signal changes and permits one bit of data to be transmitted.
baud rate	The speed of a data transmission.
Bernoulli's Principle	the statement that an increase in the speed of a fluid produces a decrease in pressure and a decrease in the speed produces an increase in pressure
beta ratio	The beta ratio or rating is used for fine filters and is determined under laboratory testing. Although not a true measure of how well a filter will do in an operating system, the beta rating is a good indicator of the filter performance. The beta ratio of an operating filter during steady state flow test is simply the count upstream divided by the count downstream of fine test dust, based on any selected particle size.
binary system	A two-digit arithmetic, numeric system commonly used in computer electronics.
blower	A low-pressure air pump used on diesel engines to increase the amount and pressure of the air coming into the engine.

	Sometimes referred to as a *supercharger.*
boost pressure sensor	This sensor measures intake manifold air pressure and sends a signal to the ECM.
boost pressure	A measure of positive air pressure provided by a supercharger or turbocharger.
bore	The diameter of an engine cylinder. Sometimes used to refer to the cylinder itself.
boundary lubrication	Thin film lubrication characteristics of an oil.
Boyle's Law	The absolute pressure of a fixed mass of gas varies inversely as the volume, provided the temperature remains constant.
brake power	Power developed by an engine measured at the flywheel measured by a dynamometer or *brake*. Factored by *torque* or RPM.
British thermal unit (BTU)	Measurement of the amount of heat required to raise the temperature of one pound of water by 1 degree F, at sea level.
broach	A boring bit used for final, accurate bore sizing.
BTM	Brushless torque motor. Caterpillar rotary proportional solenoid used for PEEC timing and rack position control.
bypass filter	A filter assembly plumbed in parallel with the lubrication circuit, usually capable of high filtering efficiencies.
bypass valve	A diverter valve fitted to full flow filter (series) mounting pads, designed to reroute lubricant around a plugged filter element to prevent a major engine failure.
burst pressure	The pressure which causes rupture. Also, the inside out differential pressure that causes out-ward structural failures.

C

cache	High speed RAM located between the CPU and main memory used to increase processing efficiency.
calorific value	The heating value of a fuel measured in BTU, calories, or joules.
calibration parameters	The specific values required when setting performance to specification.
calipers	Comparative measuring instrument used for measuring outside diameter and inside diameter.
cam ground	Trunk-type pistons that are machined slightly eccentrically. Because of the greater mass of material required at the wrist pin boss, this area will expand proportionally more when heated. Cam ground pistons are designed to assume a true circular shape at operating temperatures.
capacitance	Measure of how much electrical charge can be stored for a given voltage potential; measured in farads.
capacitor	An electrical device that can store an electrical charge or block AC and pass DC. Also known as *condenser*.
carbon (C)	An element found in various forms including diamonds, charcoal, and coal. It is the primary constituent element in hydrocarbon fuels. Atomic #6.
carbon dioxide (CO_2)	One of the products of combustion. Also a dry chemical mixture that is an excellent fire retardant. Compressed into solid form this material is known as dry ice, and remains at a

	temperature of 109 degrees F.
carbon monoxide (CO)	A deadly colourless, odorless gas that is formed when fuel is not burned completely.
carcinogen	Any substance, such as asbestos, and carbon tetrachloride, that can cause cancer.
cardan joint	A universal joint commonly used as a driveshaft coupler permitting articulation. Two yokes are united by a rigid cross whose races run in a yoke supported needle bearings or races.
case-harden	A process of heating a piece of steel to harden its surface while the inside remains relatively soft.
catalyst	A substance that stimulates, accelerates, or enables a chemical reaction without itself undergoing any change.
catalytic converter	An exhaust system device that enables oxidation and reduction reactions; in lean burn truck diesel engines, only oxidation catalytic converters are used at this moment in time.
cavitation	Describes metal erosion caused by the formation and subsequent collapse of vapor pockets (bubbles) produced by physical pulsing into a liquid such as that of a wet liner against the wall of coolant that surrounds it. Bubble collapse causes high unit pressures and can quickly erode wet liners when the protective properties of the coolant diminish. Also known in hydraulics as a gaseous condition within a liquid stream causing the rapid implosion of a gaseous bubble.
CCW	Counter-clockwise or left hand rotation.
CD	Compact disk. Optically encoded, digital data storage.
CD-ROM	An optically encoded data disk that is read by a laser in the same way an audio CD is read and is designed for read-only data.
centrifugal filter	A filter that uses a centrifuge consisting of a rotating cylinder charged with pressurized fluid and canted jets to drive it; centrifugal filters often have high efficiencies and are often of the *bypass* type.
centrifugal force	The force acting outward on a rotating body.
centrifuge	A device that uses centrifugal propulsion or a centrifugal force principle of operation.
centripetal force	Tendency to move toward a center; such as water draining from a bathtub.
cetane	A colourless liquid ($C_{16}H_{34}$). Used as a basis to test the performance characteristics of diesel fuel.
cetane improver	A diesel fuel additive designed to increase the *cetane number* rating or ignition quality. Cyclohexanol nitrate is a commonly used cetane improver.
cetane number (CN)	The standard rating of a diesel fuel's ignition quality. It is a comparative rating method that measures the ignition quality of a diesel fuel verses that of a mixture of cretonne (good ignition characteristics). A mixture of 45% cretonne and 55% would have a CN of 45. Diesel fuels refined for use in North America are classified by the ASTM as #1D and #2D and must have a minimum CN of 40.
CFM	Cubic Feet per Minute. Used as a measurement for the

	amount of air entering an engine's intake.
Charles' s Law	See Gay-Lussac's Law.
CI	Compression ignition; an engine in which the fuel/air mixture is ignited by the heat of compression.
clearance	A given space between two parts such as a piston and cylinder.
clearance volume	Volume in an engine cylinder when the piston is at TDC.
clockwise rotation	Rotation is the same as the direction as the movement of the hands of a clock.
coefficient of friction	A rating of a material's ability to generate friction. Describes the "aggressiveness" of materials in contact with each other. Affected by temperature and the presence of lubricants.
Cold crank rating (CCR)	Standard battery rating system that identifies the maximum current drain a fully charged battery can deliver at 0 degrees F or -17 degrees C - measured in cold cranking amps (CCA).
Combustion	The act of burning, *oxidation.*
Combustion chamber	In most current S.I. and C.I. engines, the engine cylinder and the geometry of the head and piston crown form the combustion chamber. In I.D.I. diesel engines, the combustion chamber is a separate cell connected to, but not integral with, the cylinder. Also, the area above the piston with the piston at TDC. Measured in cubic centimeters.
Combustion cycle	The thermodynamic process of a heat engine cycle through induction, compression, oxidation, and exhaust.
Compound	(i) A substance consisting of two or more elements held together by chemical force and not necessarily retaining any of the characteristics of the composite elements; i.e., Water: H_2O: (ii) Auxiliary gearbox that "compounds" the main transmission by increasing the available ratios and ranges.
Compression	The process by which a confined fluid is reduced in volume and increased in density with the application of pressure.
Compression ratio	The ratio of the piston swept volume to the total cylinder volume with the piston at BDC - a volumetric ratio and not a pressure ratio.
Communication Protocol	SAE has specific protocols for mobile equipment communication, such as J1939 J1587/1708
Concentric	Circles having a common centre.
Conductance	The ability of a material to carry an electrical current.
Conductors	Materials that readily permit the flow of electrons from atom to atom; usually metallic elements that have less than 4 electrons in their outer shells.
Conduction	Heat transmission through solid matter, also the transfer of heat from one object to another by being in direct contact.
Connecting rod	The rigid mechanical link between the piston wrist pin and the crankshaft throw.
Constant horsepower	Sometimes used to describe a high *torque rise* engine.
Co-requisite	A unit of learning that can be taken concurrently with another subject, but in order to be successful, both subjects must be completed successfully.

Conventional theory	(Of current flow) asserts that current flows from a positive source to a negative source. Despite the fact that it is fundamentally incorrect, it is nevertheless widely accepted and used.
Convection	A transfer of heat from one object to another through a liquid. Also heat transfer occasioned by the upward flow of hot air and the downward flow of cool air.
Counterbore	Cylindrical enlargement of the cylinder bore at the block deck to seat a liner flange.
Crankshaft	A shaft with offset throws designed to convert the reciprocating movements of the pistons into torque.
Crank throw	The offset part of the crankshaft where the connecting rods fasten.
Creep	Describes the independent movement of two components clamped by fasteners when they have different coefficients of thermal expansion or have different mass, which means their expansion and contraction rates do not concur.
Cross flow	Describes a four-stroke cycle engine breathing configuration where intake and exhaust manifolds are located on opposite sides of the cylinder head so gas flow is across the piston crown.
Crosshead	Part of the valve train in an engine that actuates two valves per cylinder. Permits two valves in the same cylinder to be opened simultaneously by a single rocker arm.
Crosshead piston	An articulating piston with separate crown and skirt assemblies in which the connecting rod is bolted directly to the wrist pin.
Crude oil	The organic fossil fuel pumped from the ground from which diesel fuel, gasoline, and many other petroleum products are refined; raw petroleum.
Current	The flow of free electrons through a conductor.
Curriculum hour	Is described as the breakdown of time for theory and practical in-school delivery. It is timed at 50 minutes per curriculum hour listed in the document.
Cycle time	A reoccurring period in which a series of actions take place in a definite order. Also used in hydraulics as the time it takes for an actuator or function to complete full extend to full retract: thus a cycle time.
Cylinder block	The main frame of any engine to which all the other components are attached.
Cylinder head	A detachable portion of an engine that covers the upper end of the cylinder bores and forms part of the combustion chamber. Also includes the valves in the case of overhead valve engines.
Cylinder sleeve	A liner or sleeve interposed between the piston and the cylinder wall or water jacket to provide an easily replaceable surface for the cylinders.

D

Damper	A unit or device used to reduce or eliminate vibration, oscillation, of a moving part, fluid, etc.

Data	Raw (unprocessed) information.
Database	A data storage location or program.
Data link	The connection point or path for data transmission in networked devices.
Data link connector	Plastic plug-in terminal with two or more electrical connections used to interface with engine or vehicle's computers.
DC	Direct current.
DCA	Diesel coolant additives. A proprietary supplemental coolant additive.
DI	Direct injection. Fuel is injected directly into the engine cylinder. This is the common means of injecting, current C.I. engines and used in some gasoline-fueled engines.
Dial indicator	Tool used to precisely measure linear travel.
Diesel cycle	A four-stroke cycle similar to the Otto cycle (intake, compression, expansion, and exhaust strokes) but where ignition of the fuel charge is occasioned by the heat of compression. A true diesel cycle engine is known as a *constant pressure* engine, meaning that fuel is metered into the cylinder at a rate that will produce constant pressure for a number of crank angle degrees.
Digital signal	An electronic signal that uses on and off pulses.
Diode	A semiconductor device that allows current flow in one direction but resists it in the other, which acts like an electrical check valve.
Displacement	The total volume displaced by the cylinders when moving from BDC to TDC.
Direct current (DC)	Electric current that flows steadily in one direction only.
Droop	An engine governor term denoting a transient speed variation that occurs when engine loading suddenly changes.
Droop curve	A required hydro-mechanical governor characteristic in which fueling drops off in an even curve as engine speed increases from the rated power value to high idle.
Dry air filter	A filter element that requires no oil or other liquid medium to trap dirt particles. Most motive power air filters are of the dry type.
Dry liners	Liners that are fitted either with fractional looseness or fractional interference that dissipate cylinder heat to the cylinder block bore and have no direct contact with the water jacket.

E

Electromagnetism	Describes any magnetic field created by current flow through a conductor.
Electron	A negatively charged component of an atom.
Electrolyte	A solution capable of conducting electrical current.
Electron theory	The theory that asserts that current flow through a circuit is by electron movement from a negatively charged point to a positively charged one. See *conventional theory*.
Electronic engine management	Computerized engine control.
Electronic control unit	Refers to the computer and integral switching apparatus in an

(ECU)	electronically controlled system. Some engine OEMs use this term rather than the more commonly used ECM.
Electronically controlled unit injector	Mechanically actuated, electronically controlled unit injector that combines pumping, electronic fuel metering, and injecting elements in a single unit.
Emissions	Any release of harmful materials into the environment. Gases produced from exhaust, crankcase, and fuel tanks and their contribution to smog.
End play	Amount of lengthwise movement between two parts due to clearance.
Energy	Any capacity for doing work.
Ethylene glycol	A liquid chemical used in engine coolant. See *antifreeze*.
Exhaust scrubber	An exhaust emission device used to clean particulate matter from engine exhaust. Used predominately in off road equipment for use in underground mining and enclosed buildings.
Expansion ratio	Ratio of cylinder volume at the moment the exhaust port or valves open to clearance volume; usually less than compression ratio.

F

Fatigue	Material failure or deterioration due to repetitive stress loading or usage.
Ferrous material	Metal containing metal or steel.
Fiber optics	The transmission of laser light waves through thin stands of fiber. Used to digitally pulse data more cheaply and at much higher speeds than copper wire.
Fire point	The temperature at which a flammable material or liquid vaporizes at a rate sufficient to burn continuously.
Flammable	Any substance that can be combusted.
Flashback	A highly dangerous condition that can occur in operating oxy-acetylene equipment in which the flame may travel behind the mixing chamber in the torch and explode the acetylene tank using the system oxygen. Most current oxy-acetylene torches are equipped with flashback arresters.
Fluid power	The term used to describe both *hydraulics* and *pneumatics*.
Flywheel	A large heavy wheel that forms the base for the starter ring gear and in which energy is absorbed and stored by means of momentum. Also provides a mounting surface for the torque converter or clutch assembly.
Force	The action of one body attempting to change the state of motion of another. The application of force does not necessarily result in any work accomplished.
Friction	The resistance an object or fluid encounters in moving over or though another.
Four-stroke cycle engine	An engine design where a power pulse occurs every other revolution of the crankshaft. These strokes are (1) intake stroke (2) compression (3) power or expansion stroke; and (4) exhaust stroke.
Full-floating	Used to describe components that permit more than the usual amount of movement-for instance a *full-floating piston pin* is

	retained in the pin boss, but permits independent movement of both the piston and the rod eye.
Full floating axle	A drive axle design where the axle shafts provide wheel torque only and bear no part of the vehicle load.

G

Gay-Lussac's Law	The law that at constant pressure the volume of a fixed mass or quantity of gas varies directly with the absolute temperature; a close approximation. Also known as Charles's Law.
General Learning Outcomes	Learning outcomes represent culminating demonstrations of learning and achievement. Outcomes are not simply a listing of discrete skills, nor broad statements of knowledge and comprehension. Outcomes describe performances that demonstrate that significant learning has been achieved and applied.
General Practices	This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the learning content.
Governor	A component that manages engine fueling on the basis of fuel demand (accelerator) and engine RPM; may be hydro-mechanical or electronic.
Grade markings	Lines placed on the heads of some bolts to indicate tensile strength.
Gross Horsepower	The brake horsepower of an engine with optimum settings and without allowing for power absorbed by the engine-driven accessories.
Gross Torque	The maximum torque produced when measured at the engine's crankshaft. Does not allow for torque consumed by the engine-driven accessories.

H

Hall Effect	A method of accurately sensing rotational speed and digitally signaling it. A rotating metallic shutter alternately blocks and opens a magnetic field from a semiconductor sensor.
Hazardous Waste	Any chemical or material that has one or more characteristics that make it hazardous to health, life, and/or the environment.
Heat	A form of energy associated with the motion of atoms or molecules and capable of being transmitted by conduction, convection, and radiation.
Helix	A spiral groove or scroll. The helical cut recesses in some injection pumping plungers that are used to meter fuel delivery. Plural: *helices*.
Hg manometer	A mercury (Hg) filled manometer.
High Idle Speed	The highest no load speed of an engine.
Hooke's Law	The law that the stress of a solid is directly proportional to the strain applied to it.
Horsepower (hp)	Measurement of an engine's ability to perform work. One horsepower is defined as the ability to move 33,000 pounds one foot in one minute.

H_2O Manometer	A water-filled manometer.
Hunting	Rhythmic fluctuation of engine RPM usually caused by unbalanced cylinder fueling.
Hydraulics	The science and practice of confining and pressurizing liquids in circuits to provide motive power.
Hydrodynamic suspension	The principle used to float a rotating shaft on a bed of constantly changing, pressurized lubricant.
Hydraulic electronic unit injector (HEUI)	Unit injector featuring a hydraulically-actuated injection pumping, with an electronically controlled injector. Combines fuel metering and injecting elements into a single unit.
Hydrocarbon	Describes substances primarily composed of elemental carbon and hydrogen. Fossil fuels and alcohols are both hydrocarbon fuels.
Hydrodynamic engine management	All engines managed without computers.
Hydrometer	An instrument designed to measure the specific gravity of liquids, usually battery electrolyte and coolant mixtures. Not recommended for measuring either in truck engine applications where a refractometer is the appropriate instrument due to greater accuracy.
Hypoid gear	A bevel gear crown and pinion assembly where the axes are at right angles but the pinion is on a lower plane than the crown.
Hysteresis	(i) In hydromechanical governor terminology, a response lag. (ii) Molecular friction caused by the lag between the formation of magnetic flux behind the magnetomotive force that creates it.

I

Impedance	The combination of resistance and reactance in an AC circuit.
Indirect injection (IDI)	Describes any of a number of methods of injecting fuel to an engine outside of the cylinder. This may be to an intake tract in the intake manifold or to a cell adjacent to the cylinder such as a pre-combustion chamber.
Indicated horsepower	Gross power produced in the engine cylinders often arrived at by calculation and always greater than *brake power* because it does not factor in pumping and friction losses.
Industry Committee	A committee of industry members who are representative of the province and help to guide the MTCU about apprenticeship issues.
Inertia	In physics, it describes the tendency of a body at rest or in motion to continue that state unless it is changed by an external force.
Inline block	An engine that has all of its cylinders aligned in a straight row.
Insulator	Materials that either prevent or inhibit the flow of electrons: usually nonmetallic substances that contain more than four electrons in their outer shell.
Integral	Whole or combined with another component to act as a single unit.

Isochronous governor	A zero droop governor or one that accommodates no change in RPM on the engine it manages as engine load varies. In electronically managed truck engines, the term is sometimes used to describe engine operation in PTO mode.
J	
Jounce	Literally "bump"-used to describe the most compressed condition of a suspension spring.
Journal	The part of an axle or shaft that actually contacts the bearing.
Jumper pipe	A term used to describe the pipes that connect the charge and return galleries with DDC MUIs or with each other in multi-cylinder heads.
K	
Kinetic energy	Any energy associated with motion.
Kingpin inclination	Inclination angle of the steering axis to a vertical plane.
Kirchhoff's 1st Law	States that the current flowing into a point or component in an electrical circuit must equal the current flowing out of it.
Kirchhoff's 2nd Law	States that the voltage will drop in exact proportion to the resistance in a circuit component and that the sum of the voltage drops must equal the voltage applied to the circuit; also known as Kirchhoff's Law of voltage drop.
L	
Lambda sensor	An exhaust gas sensor used on electronically managed, SI gasoline-fueled engines to signal the ECM the oxygen content in the exhaust gas.
Laminar flow	A condition where the fluid particles move in continuous parallel paths; streamline flow.
Lead acid battery	Standard vehicle battery consisting of lead acid cells in series. Twelve volt batteries have become standard and they can be used in multiples in parallel or series for heavy duty applications.
L-head engine	An in-line engine configuration where the intake and exhaust valve ports are located adjacent to the cylinder in the block. Seldom used in current engines.
Learning outcome	Learning outcomes are discrete statements that describe the elements leading to attainment of the general learning outcome.
Learning content	The learning activities required for the learner to achieve the Learning Outcomes. A comprehensive list of activities to guide the trainer.
Liner protrusion	The amount the liner protrudes above the deck of the block, thus allowing retention when the head is properly torqued.
Logic	(i) The science of reasoning. (ii) Arithmetic and data comparison protocols of a microprocessor.
M	
Magnetism	The phenomenon that includes the physical attraction for iron observed in lodestone and associated with electric current

	flow. It is characterized by fields of force, which can exert a mechanical and electrical influence on anything within the boundaries of that field.
Manometer	A tubular, U-shaped column mounted on a calibration scale. The tube is water or mercury-filled to balance at 0 on the scale and the instrument is used to measure light pressure or vacuum conditions in fluid circuits.
Mechanical efficiency	A measure of how effectively *indicated power* is converted into *brake power;* factors in pumping and friction losses.
Micrometer	A precision instrument for measuring either internal, external, or depth dimensions to within thousands or ten thousands of an inch or millimeter.
Micron	One millionth of a meter or .000039 inch. The term used to rate the size of filters for liquids, such as engine oil or hydraulic fluids.
Muffler	An *engine silencer* that uses sound absorption and resonation principles to alter the frequency of engine noise.
Mechanical Unit Injector (MUI)	Cam-actuated, governor-controlled unit injectors used by DDC and Caterpillar.
Multimeter	A test instrument capable of reading volts, amps, and ohms.
Multi-orifii nozzle	A typical hydraulic injector nozzle whose function it is to switch and atomize the fuel injected to an engine cylinder. Consists of a nozzle body machined with the orifii, a nozzle valve, and a spring. Used in most DI diesel engines using port helix injection pumps, MUIs, EUIs, and HEUIs.
Multiplexing	A method of using one communications path to carry two or more signals simultaneously.
N	
Nitrogen dioxide	One of the oxides of nitrogen produced in vehicle engines and a significant contributor in the formation of photochemical smog.
Non-ferrous metal	Metals and alloys that contain little or no iron.
Non-volatile RAM	NVRAM-read-write RAM device capable of data retention in cells in a vehicle module after the ignition circuit is opened; also known as KAM
Normal rated power	The highest power specified for continuous operation of an engine.
O	
O. Reg.631/94 section 3	Is an Ontario regulation for regulations as they apply to overhead cranes.
OEM	Original equipment manufacturer.
Ohm	A unit for quantifying electrical resistance in a circuit.
Ohm's Law	The formula used to calculate electrical circuit performance. It asserts that it requires 1 v of potential to pump 1 A of current through a circuit resistance of 1 ohm.
Ohmmeter	An instrument for measuring resistance in an electric component or circuit.
Opacity meter	A light extinction means of testing exhaust gas particulate and

	liquid emission that rates density of exhaust smoke based on the percentage of emitted light that does not reach the sensor, so the higher the percentage reading, the more dense the exhaust smoke.
Orifice	A hole or aperture.
Orifii	Plural of orifice.
Oscilloscope	An instrument designed to graphically display electrical waveforms on a CRT or other display medium.
Otto cycle	The four stroke, spark ignited cycle, patented by Nicolas Otto in 1876 and consisting of induction, compression, power and exhaust strokes.
Overhead camshaft	An engine which locates the valve actuating camshaft(s) in the cylinder head to either directly or indirectly actuate the valves and in some diesel applications, the unit injectors.
Oxy-acetylene	A commonly used cutting, heating, and welding process that uses pure compressed oxygen in conjunction with acetylene fuel.
Oxidation	The act of oxidizing a material; can mean combusting or burning a substance.
Oxides of nitrogen (NOx)	An undesirable compound of nitrogen and oxygen in exhaust gases. Usually produced when combustion chamber temperatures are excessively high.

P

Parallel port valve configuration	Engine cylinder valve arrangement that locates multiple valves parallel to crank centreline permitting equal gas flow through each (assuming identical lift).
Particulate trap	A canister in series with the exhaust piping containing a filtering medium to entrap diesel HC exhaust particulates and in some instances oxidize them.
Pascal's Law	A principle of fluids that states that when pressure is applied to a confined fluid, it is transferred undiminished throughout the fluid.
PC networks	Any of a variety of small personal computers designed for full function in isolation from other units but which may be used to network with other systems.
Piezoelectric Principle	Certain crystals become electrically charged when exposed to pressure, the voltage produced increasing proportionally with pressure rise. Quartz and Rochelle salt crystals have these properties. Combustion pressure sensors may both use the *Piezoelectric Principle*.
Pintle nozzle	A type of hydraulic injector nozzle used in some IDI automobile, small bore diesel engines until recently.
Plenum chamber	A chamber or cavity in which a fluid is held at a pressure above atmospheric or above system mean pressure.
Pneumatics	Branch of fluid power physics dealing with pressure and gas dynamics.
Poppet nozzle	Forward opening injector nozzle valve used on older Caterpillar IDI systems.
Port-helix metering	Consists of a pumping plunger and barrel assembly designed to regulate fuel delivery.

Potentiometer	A three-terminal variable resistor or voltage divider used to vary the voltage potential of a circuit. Commonly used as a throttle position sensor.
Power	The rate of accomplishing work; it is necessarily factored by time.
Practical	The hands-on element of learning in the curriculum document. Apprentice activities develop skills to achieve completion of psychomotor learning outcomes.
Preloading	Process of adjusting a bearing so that it has a mild pressure placed upon it, beyond zero endplay.
Prerequisite	Learning that must be achieved prior to taking a given subject.
Pressure	Force exerted per unit of area.
Pulse width modulation	The shaping of pulses and waveforms for purposes of digital signaling. Acronym PWM is often used.
Pyrometer	A thermocouple type, high temperature sensing device used to signal exhaust temperature. Consists of two dissimilar wires (pure iron and constantan) joined at the hot end with a millivoltmeter at the read end. Increase in temperature will cause a small current to flow, which is read at the voltmeter as a temperature value.

Q

Quenching	Process of dipping a heated object into water, oil, or other substance to quickly reduce its temperature.
Quiescent Combustion	Non-turbulent flame propagation characteristic of slow running diesel engines that are direct injected.

R

Radial	A line at right angles to a shaft, cylinder, etc., Centerline.
RAM	Random access memory. Electronically retained "main memory."
Rated power	The highest power specified for continuous operation.
Rated speed	The RPM at which an engine produces peak power.
Reluctor	Term describing a number of devices that use magnetism and motion to produce an AC voltage-a pick-up coil.
Rebound	Reactive response of a spring, the opposite of jounce.
Reportable Subject	(i) A clustering or grouping of related or like learning outcomes. (ii) A standalone learning unit with a distinct start and end. (iii) A course or module.
Reserve Capacity	The amount of time a battery can produce an acceptable current when not charged by the alternator.
Rheostat	A two terminal, variable resistor.

S

SAE	Society of Automotive Engineers.
SAE horsepower	A structured formula used to calculate brake horsepower data that can be used for comparison purposes.
Scoring	Scratch/gouge damage to a surface finish.
Semiconductor	A substance, such as silicon, that acts as a conductor or

	insulator, depending on its operating condition and application.
Semi-floating axle	A drive axle design in which the axle shaft imparts drive to the wheel and supports the vehicle weight.
Sensor	A term that covers a wide range of command and monitoring input (ECM) signal devices.
Shunt winding	A wire coil that forms an alternate path through which electrical current can flow.
s.i.	système international d'unités. A measure in metric units.
Silicon	A non metallic element found naturally in silica, silicone dioxide in the form of quartz.
Silicon-controlled rectifier	Function similarly to a bipolar transistor with a fourth semiconductor layer; used to switch DC.
Spark ignition (SI)	Any gasoline-fueled, spark-ignited engine usually using an Otto cycle principle.
Specific gravity	A relative weight of a given volume of a specific material as compared to an equal volume of water.
Spiral gear	A winding helical protrusion or thread machined to a shaft, as in a worm gear.
Static electricity	Accumulated electrical charge not flowing in a circuit.
Stoichiometric Ratio	The exact ratio of reactants participating in a reaction required to complete the reaction. Most often used in the context of explaining the mass of air required to completely combust a fuel.
Supercharger	Technically any device capable of providing manifold boost, but in practice used to refer to gear-driven blowers such as the Rootes blower.
Sulfur	An element present in most crude petroleums, but refined out of most current highway fuels. During combustion, it is oxidized to sulfur dioxide, and classified as a noxious emission.
Sulfur dioxide	The compound that is formed when sulfur is oxidized that is the primary contributor to sulfurous type smog. Vehicles contribute little to sulfurous smog problems due to the use of low sulfur fuels.
Supplemental Restraint System (SRS)	An emergency inflatable air bag system designed to enhance crash safety.
Swept Volume	The volume displaced in a cylinder as a piston moves from BDC to TDC.
Synthetic Oils	Petroleum based oils that have been chemically compounded by polymerization and other processes.

T

TDC	Top dead centre of an engine.
Tensile strength	Widely used term denoting the required unit stress to cause material separation. In ferrous alloys, tensile strength usually exceeds yield strength by about 10%. Measured in force per unit area, psi.
Theory	The theoretical hours listed in the curriculum document that represent learning in the cognitive domain, the thinking portion

	of the training.
Thermal Efficiency	Ratio of brake power to that of the calorific value (heat energy potential) of a material failure caused by engine performance.
Thermistor	A commonly used temperature sensor that is supplied with a reference voltage and by using a temperature sensitive variable resistor, signals back to the ECM portion of it.
Thrust faces	A term used to describe loading of surface area generally but most often of pistons. When the piston is subject to cylinder gas pressure there is a tendency for it to cock (pivot off a vertical centerline) and load the contact faces off its axis on the pin.
Torque	Twisting effort or force. Torque does not necessarily result in accomplishing work.
Torque rise	The increase in torque potential designed to occur in a diesel engine as it is lugged down from the rated power RPM to the peak torque RPM, during which the power curve remains relatively flat. High torque rise engines are sometimes described as constant horsepower engines.
Training Standards	Training standards are created by the MTCU with the Industry Committee and are intended to be used by the apprentice, instructors, and companies as a "blueprint" for on-the-job training, or as a prerequisite for government certification.
Transducer	A device that coverts energy from one power form to another for instance, a physical pressure value to an electrical pressure value.
Trunk piston	A single piece piston usually constructed of aluminum alloy.
Turbocharger	A turbine device that utilizes exhaust pressure to increase the air pressure going into the cylinders. Used particularly in reference to movement of air in the cylinder and combustion chamber.
Turbulence	A violent irregular movement or agitation of a fluid or gas. Violent swirling motion. Fuel injection provided some turbulence. Additional turbulence is provided by the design features of the combustion space.
Turbulent Flow	A condition where the fluid particles move in random paths rather than in continuous parallel paths.
Two-stroke cycle	An engine that requires one complete revolution of the crankshaft to fire each piston once. An engine requiring only one complete revolution of the crankshaft to complete the cycle of events.
U	
Unit injector	A diesel fuel injector which receives fuel at charging pressure and performs the functions of metering, creating injection pressure values and atomizing fuel-usually directly to the engine cylinder. Mechanically or electronically controlled, mechanically or hydraulically actuated.
Universal joint	A flexible joint that permits changes in driving angles between a driving and driven shaft.
Urea	the chief solid component of mammalian urine; synthesized

	from ammonia and carbon dioxide and used as fertilizer and in animal feed and in plastics
V	
Valve timing	Crank angle locations in the cycle when the valves are open and closed.
Valve train	The sum of the components responsible for actuating a valve, extending from the cam profile to the valve itself.
V-engine	Engine configuration in which the cylinders are arranged so that their axes form a V. Described by the angle, most commonly, 45, 60, and 90 degrees.
Volatility	The ability of a liquid to evaporate. Gasoline has greater volatility than diesel fuel.
Volute	A snail-shaped diminishing sectional area such as used in turbocharger geometry.
Viscosity	Denotes the fluidity of a liquid.
Viscosity Index	A measure of a liquid's fluidity at a specific temperature-diminishes as temperature drops and vice versa.
Viscous damper	An engine vibration damper consisting of disc shaped housing containing a fluid medium (silicon gel) and a solid inertia ring; uses fluid friction to dampen torsional oscillation.
Voltmeter	Instrument for testing charge differential or voltage in a circuit.
Volumetric efficiency	Engine breathing efficiency. Extent to which end gases are purged from an engine cylinder, usually expressed as a percentage of new charge to cylinder volume. A ratio of mass not volume. Seldom 100% in naturally aspirated engines, can be greater than 100% in boosted engines.
W	
Wastegate	A valve that vents excess exhaust gas to limit the amount of boost delivered by a turbocharger.
Watt's Law	Formula for computing unknown power, voltage, or current in a circuit by using two known factors to find the unknown value.
Wet liners	Cylinder block liners that have direct contact with the water jacket and therefore must support cylinder combustion pressures and seal the coolant to which they are exposed.
Wheatstone bridge	A galvanometer that bridges an electrical circuit to give a resistance reading.
Y	
Yield strength	The stress loading required to permanently deform a material-automotive construction materials, especially steels, are classified by yield strength rating.
Z	
Zenor diode	Specialty diode designed to conduct with a reverse bias current after a specific voltage value is reached.